Finding other Earths: deep planet search PAGE 42

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Vol. 32 • Issue 8

LX200GPS

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Optical Design	Schmidt-Cassegrain					Maksutov Cassegrain
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Focal Ratio	f/10	f/10	f/10	f/10	f/10	f/15
Focal Length	2000mm	2500mm	3048mm	3556mm	4064mm	2670mm
Corrector Lens	water white	water white	water white	water white	BK7	BK7
Primary Mirror	Pyrex®	Pyrex®	Pyrex®	Pyrex®	Pyrex®	Pyrex®
Price	$2,195	$2,745	$3,595	$4,995	$14,950	$2,695
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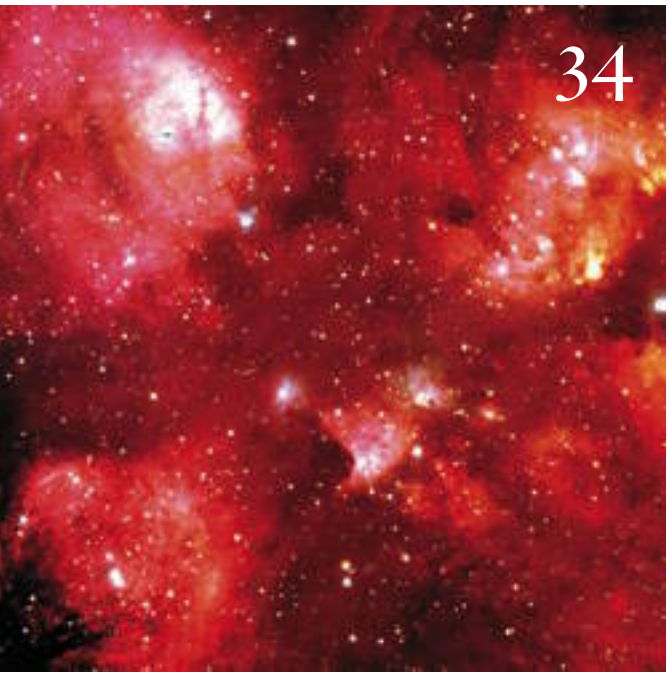
features



CFHT/J.-C. CUILLANDRE/COELUM

NASA/JPL-CALTECH/W. REACH (SSC/CALTECH)

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The telescopes used by amateur astronomers today are as good as they've ever been. Can these telescopes really be made any better? Celestron says yes, and after testing their newest Newtonian and Schmidt-Cassegrain models, so do we. PHIL HARRINGTON

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ON THE COVER
Delicate wisps and swirls of nebulosity envelop the Orion Nebula (M42), a region of hydrogen gas lying about 1,500 light-years from Earth. A massive stellar nursery that is churning out infant suns, the Orion Nebula shines bright enough to be seen with the naked eye in the night sky as a fuzzy "star" in the sword of Orion.
CFHT/J.-C. CUILLANDRE/COELUM

BY DAVID J. EICHER

Color imaging as good as it gets

The best spot for viewing the sky on

the planet? It's generally accepted to be the extinct volcano Mauna Kea on the big island of Hawaii. At an altitude of 13,796 feet, the many domes that stand scattered along the summit drink in dim starlight from the edges of space-time. One of those facilities, the Canada-France-Hawaii Telescope dome, hosts a 3.6-meter telescope that saw first light in 1979 and has been contributing to the cutting edge of astronomy ever since. The CFHT, as it's known, is by no means the largest telescope in the world — the twin, 10-meter Keck telescopes stand within walking distance — but it is optimally suited for imaging deep-sky objects in visible light. The scope is run as a consortium with astronomers from the three countries — Canada, France, and the United States — all involved and receiving observing time on the instrument.

Jean-Charles Cuillandre, an astronomer who works for the Canada-France-Hawaii Corporation, is one of the most expert astronomical imagers on Earth. Cuillandre regularly uses a special instrument on the CFHT, the CFHT12K Mosaic CCD camera, to shoot amazing, colorful images that reveal many favorite astronomical objects in a completely new light.

As captured by the CFHT and its amazing CCD array, delicate wisps of nebulosity in deep-sky objects like the Trifid Nebula take on new, sharper form and clarity; curling spiral arms studded with newborn stars in the Whirlpool Galaxy are given fresh definition.

Cuillandre's story, "Mauna Kea's colorful universe," appears on page 34 and includes a splendid gallery of 11 magnificent images of the universe as recorded by Cuillandre using the CFHT. It is a blockbuster photo essay — a very special article — that reveals images of objects unparalleled by any other instrument. After gazing at the images, you may never look at some of your favorite objects in the cosmos quite the same way again.

Thus far, 2004 has been a banner year for astronomy, with bright comets, martian rovers, a transit of Venus, and much more to come. Congratulations to two astronomers who have achieved enormous recognition by being named to TIME magazine's 100 most influential people (TIME, April 26, 2004).

Princeton University's Edward Witten, one of the most preeminent cosmologists around, was cited for his contributions to string theory. Jill Tarter, director of the SETI Institute, was named for "keeping her ears open" to the possibility of signals from extraterrestrial civilizations. They are two of the astronomy world's great stars, and both have contributed articles to *Astronomy*. All of us at *Astronomy* wish them great fortune as they carry on their important work.

Yours truly,

Dave Eicher
Editor

Astronomy

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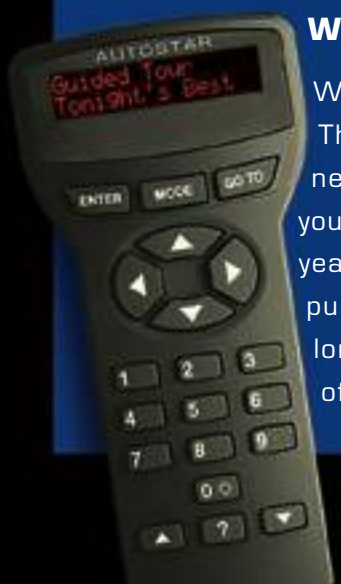

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Diffraction-Limited Optics Meade's Schmidt-Newtonian optics yield pinpoint stellar images over an extremely wide field-of-view with only half the coma of standard Newtonians of the same focal ratio.

Optical Tube Construction Schmidt-Newtonian and Schmidt-Cassegrain optics are mounted in precision-machined aluminum cells and mounted in sturdy steel tubes which are baked with high-grade textured enamel paint. The optical tube assembly is closed, reducing air currents inside the tube. This prevents distortion of an otherwise sharp image. Plus, a closed tube significantly helps keep the optics clean.

Corrector Lens Fully corrects for spherical aberration and provides pinpoint star images. Water white glass is used in all Schmidt-Newtonian and Schmidt-Cassegrain corrector lenses to maximize light transmission. The use of water white glass results in an increase of light transmission in excess of 10%, as compared to competing telescopes using soda lime glass.

Individually Figured Optics Schmidt-Newtonian and Schmidt-Cassegrain corrector lenses and mirrors are individually figured to create a superior optical system which is renowned for its exquisite smoothness and performance.

Pyrex® Primary Mirror Premium-grade Pyrex mirrors are used in all Schmidt-Newtonian and Schmidt-Cassegrain optical systems, providing exceptional thermal stability versus competing models using standard plate glass.

Fast F/Ratios Meade's Schmidt-Newtonians have extremely fast, well corrected F/Ratios for short photographic exposure times and wide fields-of-view.

*Excludes Schmidt-Cassegrain. **SC-8 AT requires optional accessory

2" Focuser Aluminum rack and pinion focuser allows the user to achieve a precise focus.*

Eyepiece Holder Accepts both 1.25" & 2" eyepieces. Allows use of all common telescope accessories and cameras.**

8 x 50 Achromatic Viewfinder Easily locate and center deep sky objects (N-6EC model includes 6 x 30 viewfinder).

Made in the U.S.A. and Performance Tested All Meade Schmidt-Newtonian and Schmidt-Cassegrain optics are manufactured at Meade's state-of-the-art facility in Irvine, California—then performance tested on an Interferometer.

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The AutoStar controller helps you quickly find, and *GoTo* over 30,000 objects in the night sky. View planets, stars, galaxies, nebulae, and comets…all at the push of a button. AutoStar is pre-programmed with several guided tours, including the popular *Tonight's Best*. Input date, time and location—then let AutoStar take you on a guided tour of the best objects that particular night. The AutoStar controller can be updated. Log on to Meade.com to download software upgrades, guided tours, and timely objects like comets—free. Keep your AutoStar up-to-date and your telescope will grow with you for years to come.

Optical Design	Newtonian	Schmidt-Newtonian					Schmidt Cassegrain	Achromatic Refractor		
Model	N-6 EC	SN-6 EC	SN-6 AT	SN-8 EC	SN-8 AT	SN-10 AT	SC-8 AT	AR-5 EC	AR-5 AT	AR-6 AT
Aperture	6" (152mm)	6" (152mm)	6" (152mm)	8" (203mm)	8" (203mm)	10" (254mm)	8" (203mm)	5" (127mm)	5" (127mm)	6" (152mm)
Focal Ratio	f/5	f/5	f/5	f/4	f/4	f/4	f/10	f/9	f/9	f/8
Focal Length	762mm	762mm	762mm	812mm	812mm	1016mm	2000mm	1143mm	1143mm	1219mm
Corrector Lens	N/A	Water White	Water White	Water White	Water White	Water White	Water White	N/A	N/A	N/A
Primary Mirror	Plate Glass	Pyrex®	Pyrex®	Pyrex®	Pyrex®	Pyrex®	Pyrex®	N/A	N/A	N/A
Viewfinder	6 x 30	8 x 50	8 x 50	8 x 50	8 x 50	8 x 50	8 x 50	8 x 50	8 x 50	8 x 50
Hand Controller	Electronic	Electronic	AutoStar #497	Electronic	AutoStar #497	AutoStar #497	AutoStar #497	Electronic	AutoStar #497	AutoStar #497
Price	$469	$639	$799	$799	$949	$1,099	$1,299	$679	$799	$999
Shipping	$75	$75	$75	$85	$85	$95	$85	$85	$85	$95
UHTC	N/A	$85	$85	$125	$125	$150	$175	N/A	N/A	N/A
Autostar Suite/LPI	$149	$149	Included Free	$149	Included Free	Included Free	Included Free	$149	Included Free	Included Free

LXD75™

No Comparison

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Sturdy Mount with Heavy-Duty Castings Designed by Meade's engineers and manufactured for high-performance observing and astrophotography.

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Astrophotography can be intimidating, but AutoStar Suite™ Lunar Planetary Imager (LPI™) lets even novice stargazers capture and process stunning images of the Moon, Saturn, Jupiter...and more.
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Patents 6,304,376 and 6,563,636
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The telescopes that have revolutionized amateur astronomy are now available with Autostar® and Field Tripod at very special low prices!

Matchless diffraction-limited optics: *Sky & Telescope* described ETX-90 optics as "excellent…stellar diffraction patterns were virtually textbook-perfect…the Cassini Division in Saturn's rings popped into view despite the rings' low tilt…Epsilon Lyrae's component stars were cleanly split…the Moon was beautiful at any magnification, with black shadows contrasting sharply with illuminated features along the terminator…the mechanics of the optical tube assembly are also first rate."

A long listing of standard-equipment features including rigid fork mounts; dual-axis drive systems with high-torque DC motors on both telescope axes; cordless field operation from eight (user-supplied) AA-batteries that power the telescope for more than 20 hours of normal usage; and internal flip-mirror system for observing or imaging from either the 90° or straight-through positions.

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Each supplied with #497 Autostar Controller and #884 Deluxe Field Tripod:

ETX-90AT Astro Telescope $595
ETX-105AT Astro Telescope 795
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Ultra-High Transmission Coatings (UHTC) group increases image brightness by about 20%: ETX-90AT– $50; ETX-105AT– $75; ETX-125AT– $95

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ETX-70AT Astro Telescope 299

Packing & shipping (ETX, Autostar, & Tripod): ETX-90AT — $30; ETX-105AT — $35; ETX-125AT — $40; ETX-70AT — $20.

Meade ETX-125AT
Shown with standard-equipment #497 Autostar Controller and #884 Deluxe Field Tripod.

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LX90

THE TELESCOPE OF A LIFETIME

Worm gears of 4.9"-diameter on both telescope axes for smooth sidereal-rate tracking of celestial objects as well as precise guiding corrections during long-exposure imaging.

Die-cast-aluminum *double-tine* fork mount that rigidly supports the optical tube in all sky orientations.

The LX90 is powered for about 60 hours by 8 (user-supplied) C-cell batteries. Alternately, the telescope may be powered from an automobile cigarette lighter plug or from a standard 115vAC home outlet, using optionally available power cords.

Rigid chromed-steel variable-height field tripod — *the same tripod provided with Meade LX200GPS models.*

Autostar™ Computer Controller: The LX90's *standard-equipment* Autostar controller permits an incredible array of telescope features:

- *Automatic GO TO capability* at 6.5°/sec on both axes, simultaneously, to 30,223 database objects, including:
- 13,235 deep-sky objects — the complete Messier, Caldwell, IC, and NGC catalogs; 16,888 stars; the 8 major planets; the Moon; 26 asteroids; 15 comets; 50 Earth satellites; plus 200 user-defined memory locations.
- *Automatic GO TO capability* to *any* object of known R.A. and Declination. Plus hundreds of special event menus, guided tours, utility functions, and telescope status options.
- *Nine selectable slew speeds:* 6.5°/sec, 3°/sec, and 1.5°/sec, as well as 128x, 64x, 16x, 8x, 2x, and 1x sidereal.
- *Control of the telescope* through your personal computer. (Requires optional #505 Connector Cable Set.)
- *Fast alignment of the telescope* using any of three alignment functions, including the Meade-proprietary Easy Align.
- *Autostar is fully upgradeable over the Internet*: add the positions of new comets, update the positions of Earth satellites, even add new software.

With diffraction-limited optics in an Autostar computer-controlled telescope system, the Meade 8" LX90 includes capabilities not available on other brands of 8" Schmidt-Cassegrains costing hundreds of dollars more. Incorporating the optical system of the 8" LX200GPS, and with 5 arc-minute pointing precision in the GO TO mode, the LX90 is fully qualified for long-exposure CCD imaging and astrophotography as well as for other advanced photo-visual applications.

8" LX90
Schmidt-Cassegrain
$1695

SPECIFICATIONS: 8" LX90 — Each complete telescope includes 8" f/10 Schmidt-Cassegrain optical tube assembly with MgF_2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally; see below); double-tine fork mount with dual-axis 4.9" worm gears and control panel; electric slow-motion controls on both axes; Autostar hand controller with digital readout display, 9-speed drive controls on both axes, and GO TO controller; 30,223-object onboard celestial software library; internal battery port accepts 8 (user-supplied) C-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); 8 x 50mm viewfinder; 1.25" diagonal prism; Series 4000 Super Plössl 26mm eyepiece; standard field tripod; Autostar Suite with imager; operating instructions. **$1695. Ultra-High Transmission Coatings (UHTC) group** increases image brightness by about 20%: add **$175.** Packing & shipping in the 48 states: $95.

The Meade 8" LX90 is manufactured under U.S. Patent Nos. 6,304,376 and 6,392,799; other patents pending in the U.S.A. and worldwide.

Included with LX90:
Meade Autostar Suite™ including LPI™ imager
A **$149** value!

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Night lights

"Capturing aurorae" (March 2004)

caught my eye. As a Weather Bureau observer/meteorologist in Alaska from 1948 to 1960, I saw many examples of aurorae. The most unusual aurora I ever saw, however, occurred around 2 A.M. one winter morning in Fairbanks. A roundish patch of aurora about twice the Moon's diameter rose in the west, moved to nearly overhead, and then set in the northeast. A second patch followed a few minutes later. From rise to set, the whole event took about 3 minutes. It was as if a giant beyond the western horizon was shooting fireworks across the sky. **— ROBERT CALDWELL,** FLAGSTAFF, ARIZONA

THE NORTHERN LIGHTS dancing across the sky are an unforgettable sight. Framed by foreground trees, this colorful aurora imitates the midnight Sun. CORY LOEWEN

Robots in space

Regarding "A new vision for space" (May 2004), I make the same case that others did when the feasibility of the International Space Station was debated before the U.S. Congress: The main reason a manned mission costs tremendously more than a robotic mission is not the life-support systems but the cost of perfection. The last 10 percent of reliability costs twenty times as much as the first 90 percent. It's acceptable to have 10 percent of robotic missions fail — but not so with manned missions.

Human engineers have created a great way to explore space. We are at a technological stage at which we can build robots to do marvelous things that are too dangerous and time-consuming for astronauts.

Yes, someday in the far distant future, humans will need to leave the nest and colonize other planets. The best way for those in our time to prepare for that is to do what we do best: explore the solar system with robots. A significant amount of scientific information can be obtained per dollar or per year through robotic means. **— CURT RENZ,** ARLINGTON HEIGHTS, ILLINOIS

Theory vs. reality

In "Frames of reference" (May 2004), Bob Berman states that black holes cannot form in our reality. I appreciate this thought-provoking idea; however, most scientists agree that black holes do exist. So, either they really can form, or they were always there. If our universe is 13.7 billion years old, then black holes can't have always existed, unless their existence is somehow separate from the rest of our universe.

The more likely explanation is that the theories we use to explain the formation of black holes are inadequate. Such theories include the standard model of quantum mechanics and Einstein's general relativity.

It has been known for some time that combining these two theories produces results that are impossible in nature, and yet, the formation of black holes requires both quantum effects and relativistic effects to be considered. The impossible situations described by the theories are merely shortcomings of the theories, not proof that black holes can't form. **— PHIL KNIGHT,** STANSBURY PARK, UTAH

Ideas of black-hole formation do not use any quantum mechanics other than the white dwarf limit that prevents further collapse for less-massive stars. It is true that general relativity, like any other theory, may be incomplete or incorrect. The very definition of a black hole, however, comes from this theory. So, if we give up on general relativity, we cannot hold on to black holes either.

The signs of a black hole (e.g., a very high-density object emitting X rays with short period variability) would be there even if the collapsing star froze just short of creating an event horizon and a singularity. Indeed, as the article made clear, the star must *freeze from our perspective because infinite time is required for black-hole formation.* **— BOB BERMAN**

We welcome your comments. Send letters to Astronomy *Letters, P. O. Box 1612, Waukesha, WI 53187; e-mail to letters@astronomy.com. Please include your name, city, state, and country. Letters may be edited for space and clarity.*

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BY BOB BERMAN

Astronomy for free?

Here it is — the year's cheapest astronomy event.

Should astronomy experiences be rated according to price like cars? Why not? Ours is a consumer society. A lot of people equate high quality with high cost. Why should the universe be different? I refer, of course, to the wonderful Perseid meteor shower on August 11. This year, the Moon won't interfere: ideal conditions. It's one of the few skywatching experiences that actually can be ruined by using a telescope or even binoculars because you need a whole-sky field of view to catch the most shooting stars. As with the northern lights, the shower just cannot be improved with fancy equipment.

The entire hobby or science of astronomy was once like that. You'd marvel at the Milky Way, learn the constellations, point out planets and watch them ramble against the starry background. But our obsession with equipment now makes it hard just to sit there and look up.

So round up your family and friends and head for the Greek island of Limnos for the Perseids. It'll sound impressive, guaranteed.

So how can we make the Perseid meteor shower expensive? After all, this is necessary if we're to convince our materialistic friends it's worthwhile.

Textbooks say amateurs still can do "useful science" when it comes to meteors. Great — but what can we buy, what do we do? Easy, just count the meteors each hour.

Count them? That's it?

All right, there's *some* equipment for this event. A red LED console attached to a button can keep a running total without having to keep track yourself. But while such a gizmo is cool, it just isn't pricey.

So how's this: an EKG that blips and counts each time you gasp? Because bright meteors make everyone draw an involuntary breath, that would work. Or perhaps we could attach that LED counter to a headset microphone running to a decibel meter registering sound, so it tallies each time anyone proclaims, "Whoa!" or "Did you see that one?"

Still too cheap? Then travel. Meteors are much better from the country than the city, so you need to go somewhere to optimize the experience. A desert is absolutely optimal. How about Chile? Think I'm joking? Look at the ads. There are more and more overseas-adventure-type astro-expeditions organized around events that you can see from home. I've been the lecturer on a bunch of them. When Comet Hale-Bopp came around a few years back, Tom Bopp, Fred Whipple, and I did a "Comet Cruise" to the Caribbean. It was packed, despite the fact that you'd see the comet just as well from Kansas. So round up your family or friends and head for the Greek island of Limnos for the Perseids. It'll sound impressive, guaranteed, and the meteors will be appreciated much more when they cost a hundred bucks apiece.

(While this is all tongue-in-cheek, there's truth behind it. A long time ago, I'd let friends attend my college classes for free. Then I discovered that they were the only students who would arrive late or raise their hands and wisecrack. I finally realized that many people do not value what they get for nothing. I started insisting that friends pay to attend the lectures like everyone else, and *wham!*, their attitude in class totally changed.)

So forget Messier-type catalogs with objects listed by magnitude, right ascension, or distance. We need to classify astronomy targets by cost of enjoyment!

Top-rated event: a total solar eclipse. You always must travel, and the trip is usually more than $3,000 for a 3-minute event. So an eclipse costs $1,000 a minute. No wonder they look so awesome.

This is why the great 1991 Baja eclipse, which lasted nearly 7 minutes, and which you could drive from Los Angeles to see, gets a low rating. That one set some people back only $70 a minute. It went on and on. We were tempted to read paperbacks by the light of the corona just to kill time until it was over.

Next: the Magellanic Clouds and other Southern Hemisphere delights. These can't be seen from the United States; you have to journey south of the equator. That's pricey.

Then come super-faint goodies like the crimson color of emission nebulae. For a direct view at the eyepiece, they require big apertures. Expensive equipment. In deep space, seeing red is a status thing. Like paying extra for a particular paint scheme on a motorcycle.

Meanwhile, maybe we can upgrade the meteors by finding sponsors for them. *Pepsi brings you the Perseids!* Alas, for this year at least, the shooting stars remain free. Let's try to enjoy them anyway.

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BY GLENN CHAPLE

A ring and a triangle

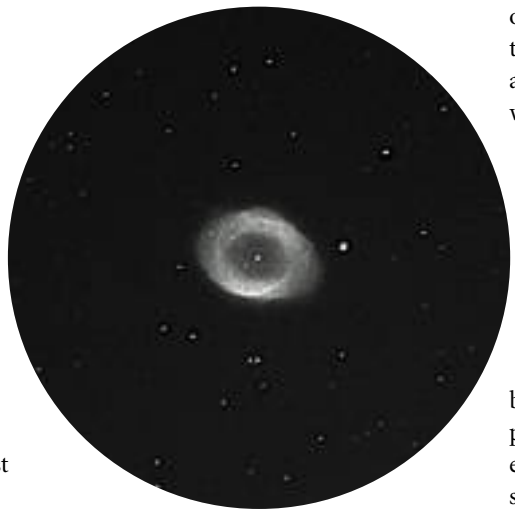
Greetings all you seekers of

astronomical knowledge. It's time for another edition of Professor Chaple's pop multiple-choice astroquiz: Is a triangle a three-sided geometric figure? A musical percussion instrument? Or, is a triangle Vega, Altair, and Deneb? If you answered "yes" to either of the first two, you're wrong —

at least from an astronomical viewpoint. "Vega, Altair, and Deneb" is the right answer. These three bright stars make up the Summer Triangle, which currently is visible in the evening sky. Traversed by the Milky Way, the Summer Triangle is rich with telescopic treats, some of which are easy targets for the beginner.

Prepare for your Summer Triangle excursion with a naked-eye survey of these stars and their parent constellations. The all-sky map on page 59 will help. Start with Vega, the brightest Summer Triangle member. From mid-northern latitudes, this star appears almost directly overhead after sunset. Vega teams up with a compact parallelogram of stars nearby to form the constellation Lyra the Lyre. A line from Vega through this parallelogram points the way to Altair, part of an even larger stellar parallelogram that defines the constellation Aquila the Eagle. Altair is easily recognizable because it's the centerpiece of a row of three bright stars. If you follow the Milky Way northward from Aquila, you'll arrive at the third Summer Triangle star, Deneb, and its parent constellation, Cygnus the Swan. Deneb and four other Cygnus stars form a popular asterism known as the Northern Cross.

Deneb may appear to be the dimmest Summer Triangle star, but it's actually the brightest — by far. Vega and Altair, at distances of 25 and 17 light-years, respectively, are relative neighbors of ours. Deneb, on the other hand, is 1,800 light-years away. Were Deneb as near as Vega and Altair, it would be an absolutely dazzling sight — a blazing beacon dozens of times brighter than Venus, which is visible in daylight. Huge, hot stellar infernos like Deneb have relatively short (for stars) life spans of a million years or so. They end their lives in spectacular fashion as supernovae. Let's be glad Deneb is as remote as it is!



THE RING NEBULA (M57) can be a tricky target for a novice observer. It appears as a faint, white oval through a small scope. JOHN O'NEILL

Once you've scouted the Summer Triangle with the naked eye, it's time for a binocular and telescopic close-up. Again, start with Vega. Stars don't look larger when they're viewed with optical aid, but they *appear* brighter. Vega is beautiful — a sparkling, pure-white gem. Altair and Deneb also gleam like diamonds. All three are white-hot stars of spectral class A.

While gazing at Vega with binoculars, you might notice a double star close by. This is Epsilon (ε) Lyrae. If you study Epsilon Lyrae with a telescope, with magnification around 100x, you'll discover each star is actually a double star. Dubbed the "Double-Double," Epsilon Lyrae is one of the night sky's finest sights.

So is Albireo, the star at the base of the Northern Cross. Albireo is a must-see double star that is famed for its beautiful colors. The brighter one is topaz-yellow, while the companion gleams sapphire-blue — a sight sure to evoke a gasp from anyone who thinks all stars are white. The colors seem richest when viewed with a small telescope and a magnifying power from 30x to 50x.

Our final Summer Triangle treasure is M57, the Ring Nebula. When a star of average size dies, its core abruptly collapses while the outer layers are shed as an expanding shell of gases. This gas bubble can remain visible for centuries as a planetary nebula. M57 is one of the finest examples. Bright enough to be visible in a small telescope, the Ring Nebula can prove elusive for the novice skygazer. Here's a strategy to help you capture the Ring. Aim your finder scope toward M57's lair, midway between the stars Gamma (γ) and Beta (β) Lyrae. With a low-power eyepiece in place, slowly sweep the area, looking for a small, oval patch of light. Once you find it, center it in the field of view, then switch to higher power. In small scopes, the Ring Nebula appears as a solid, ghostly white oval. Its annular (ring) appearance is visible only through 6-inch scopes or larger.

If you have a topic you'd like me to address in a future column, let me know. Be sure it relates to skygazing at the beginner's level. E-mail me at *gchaple@astronomy.com* if you want to share your idea with the staff at the magazine, or at *gchaple@hotmail.com* to reach me directly.

Next month: We try a little "VSO-ing." "What's that?" you ask. Check back next month. Clear skies.

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BY WILLIAM SCHOMAKER

Xiaohui Fan

University of Arizona astronomer

Xiaohui Fan isn't content pursuing his celestial quarry from bite-size distances of thousands or even millions of light-years away — he'd rather imbibe the history of the universe with one giant gulp. « Fan's hunger for probing the outer limits of optical astronomy ripened as a child and amateur

astronomer observing from rooftops in his hometown, Beijing, China, and hasn't staled since. With aid from the Sloan Digital Sky Survey (SDSS), an ambitious, multi-national collaboration, he's discovered 13 of the most distant quasars known, and he vows to keep looking deeper into the universe and the past until he spies the first generation of quasars.

Why are you obsessed with distance?

As an amateur astronomer growing up in China, I always felt that the truly exciting aspects of astronomy could be found in the farthest, biggest things we can see. But it wasn't until I started doing my senior thesis in college — on the colors of high-redshift quasars — that I began to study the universe's most remote and exciting objects seriously.

How does the SDSS help you probe the outer limits of optical astronomy?

The major difficulty with discovering distant objects like quasars is that they are both very rare and very faint. In fact, we find only one high-redshift quasar for every four hundred to five hundred square degrees of sky that we survey. And that's where the SDSS comes in — covering ten thousand square degrees of sky down to about magnitude 22.5.

Another advantage of a powerful survey like the SDSS is that it uses five optical filters to take color images of the sky. This gives us wide wavelength coverage to measure colors for a variety of celestial objects, from nearby asteroids to distant quasars.

XIAOHUI FAN has an insatiable appetite for such cosmic delicacies as uberbrilliant high-redshift quasars. DAVID HARVEY

So that's how you got into studying nearby brown dwarfs?

Yes. Our technique involves looking for objects that appear to be stellar but have quasar-like colors. The most distant, and consequently faint, quasars have the reddest color. But brown dwarfs, because of their low temperatures, are also quite red and faint. So the SDSS high-redshift quasar survey turns out to be successful in the hunt for brown dwarfs, initially because these brown dwarfs are unavoidable "contaminants" of our quasar survey (or vice versa if you are a brown-dwarf person!).

I find it curious that at first sight, high-redshift quasars — among the most luminous and most distant objects in the cosmos — would look so similar to brown dwarfs, among the faintest and the closest objects known. It's a coincidence, but sometimes you can't help thinking the universe is working in mysterious ways.

What will first-generation quasars tell us about the universe today?

First-generation quasars will tell us when and how the first generation of supermassive black holes formed in the universe and how these black holes are related to the formation of the galaxies that host them. Secondly, using distant quasars as background light sources, we will be able to probe the physical status of primordial gas between Earth and quasars to discover how the "thermal" state of the universe has evolved.

One of the most surprising results we have seen is that even the highest redshift quasars have spectra almost identical to those at much lower redshifts; this means quasars seem to have matured very quickly. But will first-generation quasars still look the same? I think the answer to that question will tell us a lot about how supermassive black holes formed.

Can you give us a sneak preview of where the black hole evidence is leading you?

My opinion is that the formation of supermassive black holes and the formation of their host galaxies are results of the same process, and their formation and evolution affect one another. We see a lot of evidence, although some still tentative, that early quasars are accompanied by strong, galaxy-scale star formation. And closer to home, astronomers find the masses of supermassive black holes seem to constitute a fixed fraction of host-galaxy masses. A

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Sweepstakes Entry. To enter, complete and mail the official entry form or a postcard with name, address, city, state or province, zip and telephone number on a postcard and sent it to: Astronomy Summer Sweepstakes, P.O. Box 378, Waukesha, WI 53187-0378. Or enter online at www.astronomy.com by filling in the Online Entry form and hitting the SEND key. The Online Entry form must be filled out completely to be eligible. Incomplete or defaced entry forms are void. One entry per household. The official ending date for the Astronomy Summer Sweepstakes is August 6, 2004, and all entries must be transmitted or postmarked no later than that date.

Prizes and Odds of Winning. One drawing will be held on or about August 30, 2004, for the following awards: One Grand Prize consisting of a NexStar 11 GPS Telescope (retail value $3,000.00). Two First Prizes consisting of a NexStar 8i Kit (Telescope, Tripod, Computer Hand Control) (retail value $2,150.00). Three Second Prizes consisting of a NexStar 80 GT Telescope (retail value $616.67). Four Third Prizes consisting of a SkyMaster 15x70 Binoculars (retail value $125.00). Cash equivalents of merchandise will not be awarded. Substituting prizes is not allowed. Any applicable federal, state and/or local taxes are the responsibility of the winner. Odds of winning depend on the number of entries received. Total circulation for Astronomy Magazine is 155,064. Sweepstakes void in Quebec and void where prohibited.

Validation and Acceptance. Winners in the Astronomy Summer Sweepstakes will be selected in a random drawing conducted by an independent judging organization whose decisions are final. Canadian prize awards subject to skill test requirement. By entering the sweepstakes, participants agree to be bound by these official rules and all decisions of the judging organization. Sweepstakes entries void if not legible, not completed in full, not obtained legitimately, or if forged, photocopied, mechanically reproduced, late or tampered with. The potential winners must sign and return an Affidavit of Eligibility, publicity release and Release of Liability within fourteen (14) days of notification. In the event of noncompliance, alternate winners will be randomly drawn. No responsibility is assumed for lost, stolen, misdirected or late entries or notifications. All sweepstakes entries become the property of the sponsor and will not be returned.

Winner's List. For a list of winners, send a stamped, self-addressed envelope to: Astronomy Summer Sweepstakes Winners List, P.O. Box 1612, Waukesha, WI 53187-1612. Residents of FL, VT and WA may omit stamp. Requests must be received by September 30, 2004. Or check the Astronomy Web site (www.astronomy.com) after February 1, 2005.

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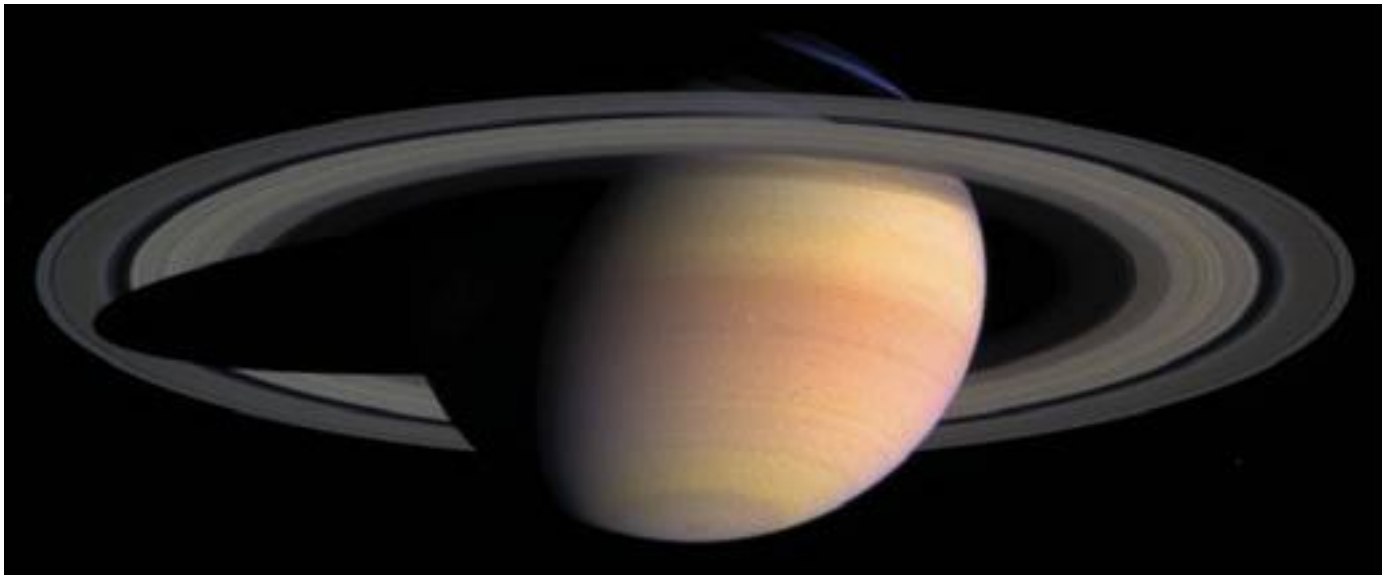
NUCLEAR FUSION RUNS MORE SLOWLY than physicists thought, according to new experiments. If confirmed, the finding would indicate the universe is a few percent older than the accepted figure of 13.7 billion years.

news 08

Read all about it: a hot star smothering in icy hailstones, the goo on Saturn's two-faced moon, a newly discovered spiral arm of the Milky Way, a big impact long, long ago, and blushing asteroids.



ALL OF SATURN AND ITS RINGS fill this Cassini view taken March 27, 2004. It was the last to capture the whole planet with the narrow-angle camera. NASA/JPL/SSI

26 A probe to hit the Moon and look for water

28 An impact that nearly ended life on Earth

30 A distant star with Sun-like activity cycles

32 Slabs of rock on Mars

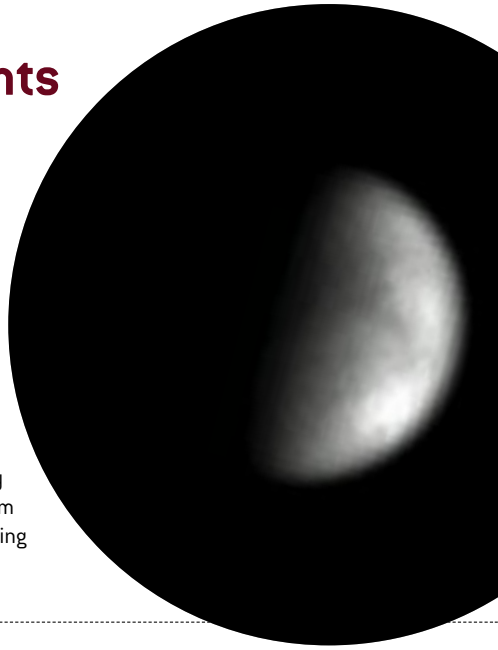
PLANETARY EXPLORATION

Cassini: Saturn, Titan in sights

The Cassini-Huygens spacecraft, launched in 1997, finally reached Saturn on July 1, firing its rocket and entering orbit. Later this year, the Huygens probe will drop into the atmosphere of the planet's largest moon, Titan.

"We've spent a lot of time on this mission," says science planner Trina Ray (JPL). "Now that things are starting to happen, it's very exciting." Titan is a priority, notes Carolyn Porco (Space Science Institute), imaging team leader: "That we can see the surface now with simple image processing says to expect sights on Titan never seen before."

— PAMELA ZERBINOS



TITAN'S SURFACE shows faintly in this far-encounter image from Cassini made at haze-penetrating infrared wavelengths. NASA/JPL/SSI

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STELLAR ASTRONOMY

Ice smothers fire

WALLS AND WISPS of gas wrap around a very hot, dying star in NGC 6302. Studies with the Hubble Space Telescope show the star is covered by icy debris from the nebula. ESA/NASA

The Bug Nebula, NGC 6302, is one of the most brilliant and intense planetary nebulae known. Resembling a butterfly, NGC 6302 holds at its heart a dying star covered by a blanket of icy hailstones.

"What caught our interest was the mixture of minerals and crystalline ice — hailstones frozen onto small dust grains," explains Albert Zijlstra (Univ. of Manchester, England), head of a team of astronomers probing the nebula.

Writing in an upcoming issue of *Astronomy & Astrophysics*, he says few objects have such a mixed composition. The inner nebula contains hydrocarbons, iron, carbonates such as calcite, and water ice. Astronomers think the nebula is about 10,000 years old.

The HST image shows walls of dense gas with trailing wisps and cascading outflows. At the center is a hot star with a temperature of 450,000° Fahrenheit (250,000° Celsius). The star has never been seen, being blocked by dust and shining most brightly at hard-to-view ultraviolet wavelengths. **— JEREMY McGOVERN**

Going roughly into the lunar polar night

The last thing most space probes want to do is crash, but for one particular design, that's the plan: A super-hardened instrument package slams into the ground of a target world to stop. Call it lithobraking.

If the impact speed is 1,000 feet per second and the probe stops in 10 ft, the deceleration is about 1,500 Gs. Electronics have been built to withstand such shocks in "bunker buster" military systems for many years.

For space missions, such probes are called penetrators, and a number have been launched in the past decade. None have worked, but it's probably not due to any design flaw — they either didn't get far enough to attempt a landing or (as with the Deep Space 2 microprobes at Mars) they sank out of radio range into too-soft soil.

Now NASA is considering a new proposal that combines the engineering approach of a penetrator with a scientific puzzle that is genuinely "underground" and which would be difficult to reach by any soft-landing vehicle on the surface. The Polar Night mission would send a probe into the lunar regolith inside one of the permanently shadowed polar craters. It would seek evidence of trapped volatile materials including water.

And not just water. According to the scientists who proposed Polar Night, their computer models indicate that "water ice at shallow depths can persist for geologic time," even under sunlit soil. Furthermore, in shadowed craters, it stays cold enough to retain "extremely volatile ices including carbon dioxide, methane, ammonia, [and] sulfur dioxide." These may even have formed organic molecules, but there's no way to tell this from orbit or even from standing on top of the regolith.

FINDING VOLATILES SUCH AS WATER in the Moon's polar regions is the goal of the proposed Polar Night mission. The spacecraft features an orbiter plus three impactor probes. NASA AMES

As proposed, Polar Night will study the lunar poles from orbit for several months to pinpoint the richest areas of buried volatiles. Three separate penetrators will be deployed in sequence, each with a descent stage to aim it precisely and slow it to about 250 ft/sec, resulting in a 300-G impact. A mass spectrometer and neutron spectrometer on each probe will determine the local chemical composition and abundances plus the isotopic ratio of volatile materials the probe finds.

At present, Polar Night remains merely a proposal for NASA's low-cost Discovery Mission series. But with renewed interest in the Moon based on the new White House space plans, the mission looks like a good bet. If approved and funded, it could fly within 3 years. **— JAMES OBERG**

actual screen view

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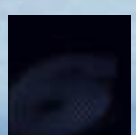

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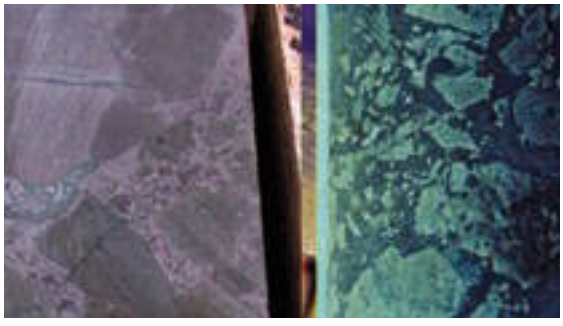
THE HUBBLE SPACE TELESCOPE may be able to see extrasolar planets directly, if tests check out. HST would image a suspect star, roll slightly, and shoot again. Ideally, imaging defects would cancel and an exoplanet may appear.

PLANETARY SCIENCE

Was the "Great Dying" caused by an impact?



BROKEN FRAGMENTS of rock in a glassy matrix in two core samples suggest similar origins: a meteorite impact. On the left is a sample from Bedout, on the right is Chicxulub. UCSB, L. BECKER

Earth's worst extinction occurred 251 million years ago, at the end of the Permian period, when 90 percent of marine species and more than 70 percent of life on land died. A team led by Luann Becker (Univ. of California, Santa Barbara) writes in *Science* (May 13, 2004) that a probable impact crater off Australia accompanied the event.

Most scientists accept that Chicxulub, a buried crater on Mexico's Yucatan Peninsula, accompanied the extinction of the dinosaurs 65 million years ago. But evidence for a similar blow ending the Permian was weaker.

The new evidence comes from two cores drilled in an undersea structure called the Bedout (pronounced "Bedoo") High. The cores date from the end of the Permian but were identified as volcanic. After another look, Becker was sure the rock was an impact melt. "We left convinced Bedout was our crater," she says.

Most compelling were large grains of shocked quartz in Australian Permian sediments. Shocked quartz contains microscopic fractures and is widely considered a good tracer of meteorite impacts. From seismic and gravity data, the scientists believe Bedout is about 120 miles (195 kilometers) wide, about the same as Chicxulub.

"This is very likely the impact site we've been looking for," says coauthor Robert Poreda (Univ. of Rochester). The picture is complicated, however, by a huge basalt eruption at the same time in Siberia under massive coal beds. The CO_2 released by this event may have changed Earth's climate for the worse. — **FRANCIS REDDY**

PLANETARY SCIENCE

Two faces of Iapetus

As the strange moon Iapetus orbits Saturn, its dark side is always in front, while the trailing face is ten times brighter. A team of scientists writing in *Science* (April 23, 2004) used Arecibo as radar to scan the moon, finding little difference in reflectivity between its two sides.

This suggests the dark material on the leading side is dust or organic debris in a layer only a few inches (centimeters) thick. This coating probably was shed by nearby saturnian moons.

The team also thinks ammonia-rich material at shallow depths would explain the moon's low radar reflectivity. — P. Z.

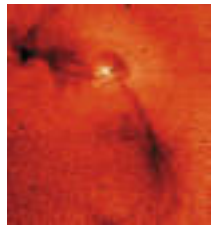
A DUSTING of organic debris over ammonia-rich ice darkens half of Iapetus. NASA/JPL

HIGH-ENERGY ASTROPHYSICS

X-ray plumes in M87

NASA's Chandra X-ray Observatory has seen plumes, bubbles, and jets of gas spanning thousands of light-years in the heart of M87, a giant elliptical galaxy in the Virgo cluster.

Gas falling toward the galaxy's central black hole produces a magnetized jet that blasts high-energy particles into space at near the speed of light. As the jet plows into surrounding gas, it creates a buoyant, magnetized bubble of particles. Some astronomers think faint, ring-like features in the new Chandra image may be caused by intense sound waves rushing ahead of these expanding bubbles.



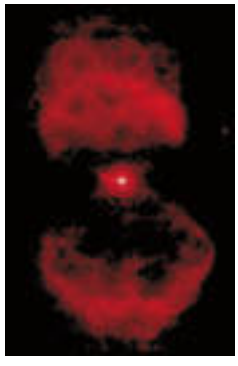
A MAGNETIZED JET in M87 glows brightly in X rays. NASA/CXC

Curved plumes of X-ray emission extend more than 75,000 light-years from the galaxy's center. — **F. R.**

GALACTIC ASTRONOMY

First light for VISIR instrument

Astronomers at the European Southern Observatory's Paranal Observatory in Chile reported "first light" — or, more accurately, "first heat" — for a new infrared instrument mounted on its 8.2-meter Very Large Telescope (VLT). The VLT Imager and Spectrometer in InfraRed (VISIR) can detect dust particles at temperatures of –200° to +300° C (–330° to 570° F). Many important astrophysical processes, including star formation and evolution, occur in regions obscured by dust, and infrared astronomy allows astronomers to peer into these otherwise hidden regions.



THE ANT NEBULA (Mz3) is a planetary nebula whose bipolar shape, seen here with the VLT's VISIR, hints that the central star has a ring around it. ESO

Although NASA's Spitzer Space Telescope also sees in the infrared, the high cost of space-based instruments kept its diameter to 0.85m, giving it a resolution only one-tenth that of the VLT's. — **P. Z.**

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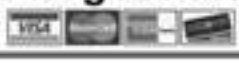
We Accept  Telescopes, Accessories & much more!

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STUDIES OF HYDROGEN-ATOM SHADOWS in the cosmic microwave background are helping astronomers probe the "Dark Ages," a post-Big Bang period when the universe was opaque to radiation and the first stars were forming.

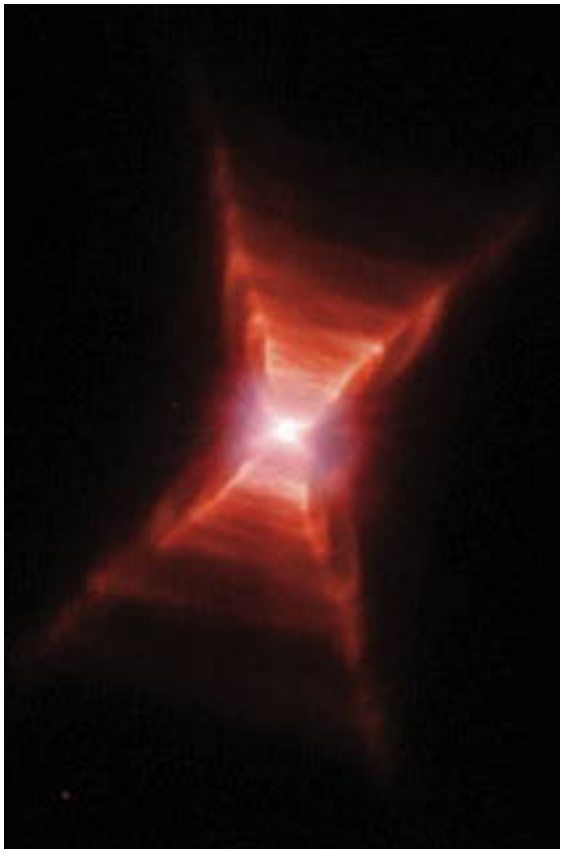
STELLAR ASTRONOMY

Rungs of gas and dust

The Hubble Space Telescope has revealed ladder-like structures around a dying star in a nebula known as the Red Rectangle. Cataloged as HD 44179, this nebula is known for its shape and color, which is visible through ground-based telescopes — but the Red Rectangle isn't rectangular after all.

Instead, it's shaped like an X, which astronomers are interpreting as the product of gas and dust outflows from the star in the center. The star ejects gas and dust in opposite directions, producing a shape like two wineglasses touching at their bases.

The crossbeams of the X are joined by straight features resembling rungs on a ladder, giving the Red Rectangle a spider-web appearance. These rungs have a regular appearance that astronomers think was caused by mass ejections from the star every few hundred years. The reasons for these periodic ejections remain unknown. — **P. Z.**



PERIODIC EJECTIONS of dusty gas built "rungs" in the nebula known as the Red Rectangle. It lies 2,300 light-years away in the constellation Monoceros. NASA/ESA/H. VAN WINCKEL, M. COHEN

STELLAR ASTRONOMY

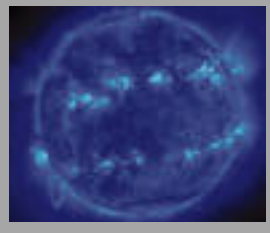
Distant star has Sun-like X-ray cycle

The XMM-Newton X-ray satellite observatory has detected Sun-like, cyclic activity in a distant star's X-ray emission.

HD 81809 is a binary star of the same spectral type as the Sun. XMM-Newton has monitored it for 2.5 years and found a tenfold change in its X-ray emission. The emission peaked in 2002 and has declined since.

A team of astronomers led by Fabio Favata (ESA) is watching for changes in several Sun-like stars using XMM-Newton.

"We may have caught HD 81809 at the start of an X-ray activity cycle," he says. — R. B.



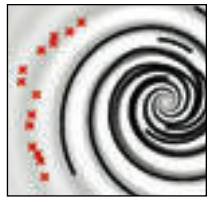
CHANGES in solar X-ray brightness also may occur in other Sun-like stars. NASA/ESA

GALACTIC ASTRONOMY

Milky Way adds a "new" spiral arm

The Milky Way has an additional distant spiral arm, 77,000 light-years long and several thousand light-years wide, according to a group of astronomers led by Naomi McClure-Griffiths (Australia National Telescope Facility). Their results appear in *Astrophysical Journal Letters* for June 1, 2004.

As mapped, the arm runs from Vela to Norma in the southern sky. The arm, however, is visible only in radio telescopes, which detect its neutral-hydrogen emission.



THE NEW SPIRAL ARM of the Milky Way (red Xs) lies outside the others. ANTF

The arm's sideways jog (see above) may reflect the pull of the Magellanic Clouds' gravity. It also might be the result of a close passage by another small galaxy. — **R. B.**

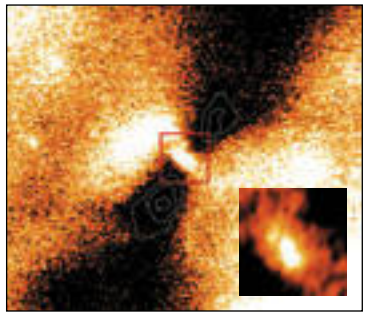
STELLAR ASTRONOMY

Shadow sheds light on star-making

A team of astronomers led by Rolf Chini (Ruhr-Universität Bochum, Germany) has shown that high-mass stars can form the way low-mass stars do: through accretion in a circumstellar disk.

The team used infrared wavelengths to peer into a star-forming region in M17. Associated with an hourglass-shaped reflection nebula was a silhouette resembling a flared disk seen almost edge-on.

The astronomers interpret this as a new, high-mass star surrounded by a huge accretion disk and accompanied by an energetic bipolar outflow of material. The disk spans more than 20,000 AU and has a mass of about 110 suns, making it the largest circumstellar disk ever detected. — **P. Z.**



A HUGE DISK around a new, high-mass star is supporting theories that stars of up to 40 solar masses form the same way that low-mass stars do. ESO

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Alaskan aurora photograph by Mike O'Leary

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A LUNAR METEORITE THAT FELL IN 2000 contains a newly identified mineral called hapkeite. The mineral mixes iron and silicon in a 2:1 ratio and forms as a glassy deposit on airless bodies. It may contribute to space weathering.

Landslides in Tiu Vallis

SLOPE FAILURES DUMPED debris on the floor of Tiu Vallis long enough ago for at least one landslide to be lightly cratered. This Mars Odyssey THEMIS image was taken near 15° north and 327° east as part of a student research project. See *msip.asu.edu* for more details about the project. NASA/JPL/ASU/IMAGE 20040426A

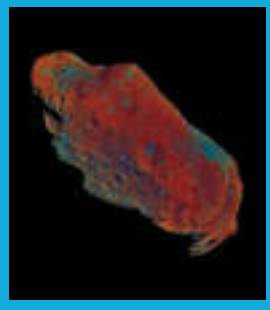
PLANETARY SCIENCE

Blushing asteroids

Asteroids redden as they age, confirming a long-suspected notion that space somehow "weathers" rocks exposed to it.

Writing in *Nature* (May 20, 2004), a team led by Robert Jedicke (Univ. of Hawaii) says they identified families of asteroids (and their ages) using orbital elements. Families having similar ages show similar colors, and the colors appear redder in the older families.

What causes space weathering, however, remains partly a mystery (but see above). — F. R.



REDDER MEANS OLDER in this false-color view of asteroid Ida's surface. NASA/JPL

MARS PHOTOJOURNAL

ISLANDS IN A VALLEY, two old impact craters stand in the middle of Marte Vallis, a martian outflow channel. The valley floor has a platy texture that some scientists say is volcanic in nature; others suggest the plates are the remnants of mud flows. The image, sunlit from the lower left, is 1.9 miles (3 km) across. NASA/JPL/MSSS/IMAGE E13–00851

PLANETARY SCIENCE

Roving Mars with Opportunity

Mars rover Opportunity has found layers of basaltic sandstone in Endurance Crater in Mars's Meridiani Planum.

Also, on the crater's outer slope, which is oddly free of ejecta, lie large slabs of sulfate-bearing rock and countless hematite-rich "blueberries." See *www.lyle.org/mars*. **— R. B.**

PAVING BLOCKS? The rim rocks once were the floor of a shallow sea covering Meridiani. NASA/JPL/CORNELL

Understanding the Universe: An Introduction to Astronomy *and* What's New in Astronomy, 2003

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—Albert Einstein

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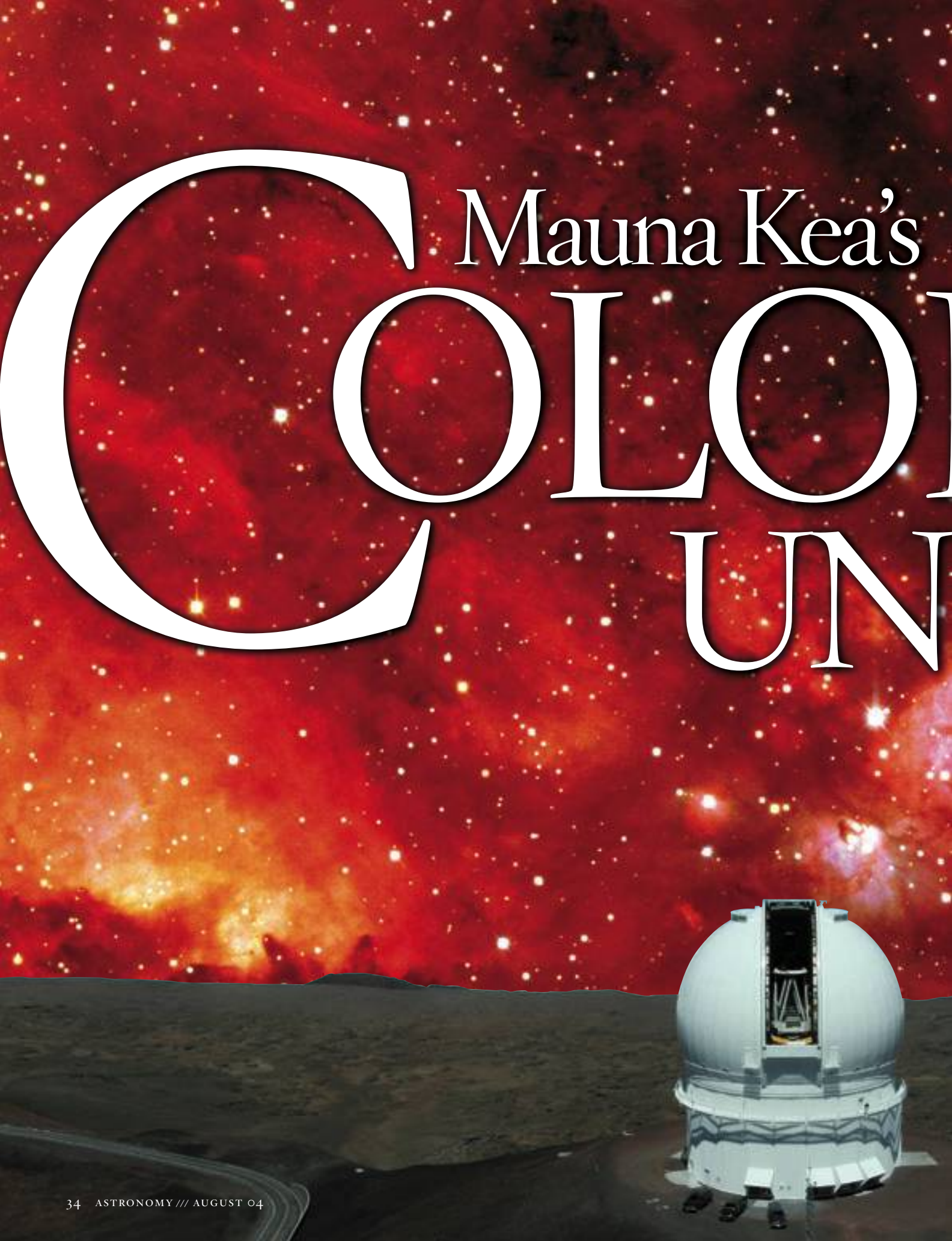
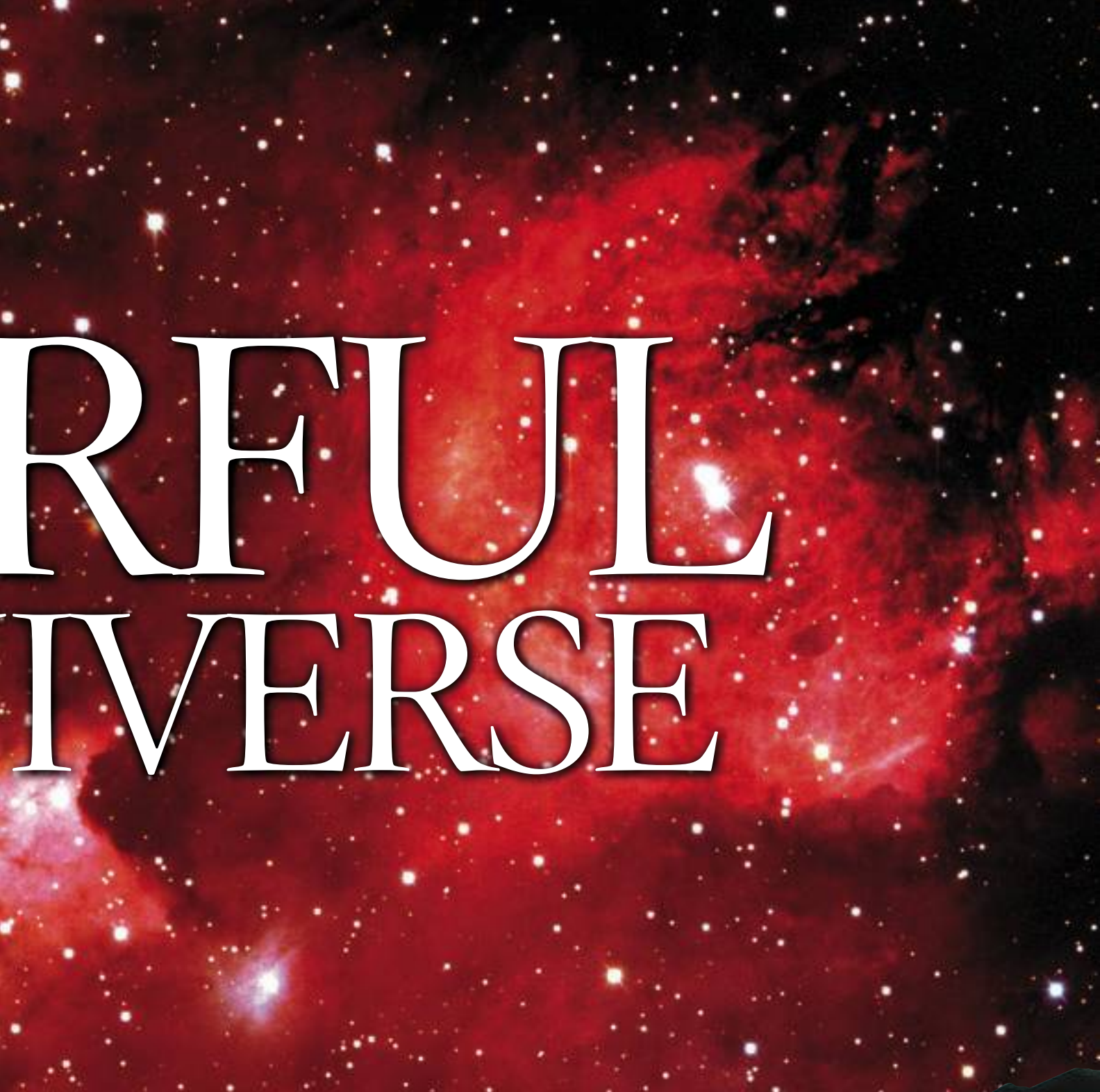




RFUL IVERSE

Astronomers at the Canada-France-Hawaii Telescope are producing stunningly beautiful images that also pack scientific punch.

/// TEXT BY JEAN-CHARLES CUILLANDRE; IMAGES COURTESY CFHT/J.-C. CUILLANDRE/COELUM

For the longest time,

magazine editors and other image-starved members of the media complained about the lack of visual material in astronomy. Indeed, after the death of photographic plates, which were replaced by electronic detectors in the 1980s, low-resolution, false-color images of the deep sky were produced with little thought given to aesthetics. In the 1990s, however, the Space Telescope Science Institute was the first to understand the great potential for stunning digital images taken through the eye of the Hubble Space Telescope.

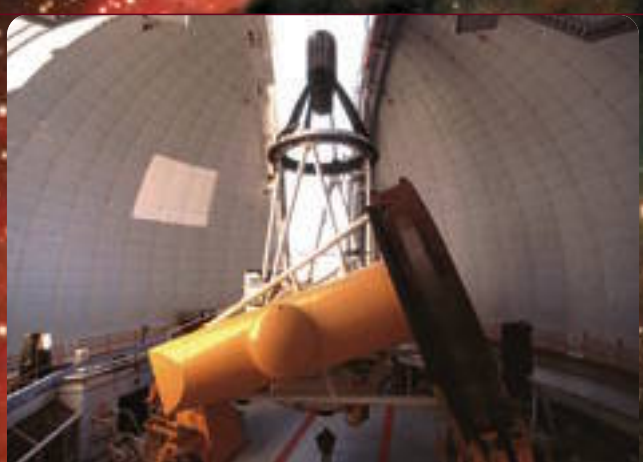
Here on Earth, the Canada-France-Hawaii Telescope (CFHT) atop Mauna Kea, Hawaii, has been the leader in ground-based, high-resolution, wide-field imaging for the past decade. Besides the prime mission of furthering key scientific programs such as studying dark matter and dark energy as well as investigating the origin of the solar system by probing the Kuiper Belt, the CFHT also happens to be the perfect tool for producing crisp and colorful images of the sky.

Wide-field CCD imaging at the CFHT

The CFHT was designed in the mid-1970s as a highly versatile telescope able to accommodate the needs of the scientific community. The first detector of choice for imaging was the photographic plate, but it was quickly discarded when the first charge-coupled devices (CCDs) appeared on telescopes in the early 1980s. The benefits of this change are obvious: The CCD is forty times more sensitive to light than photographic film and outputs a digital signal that is manageable by computers.

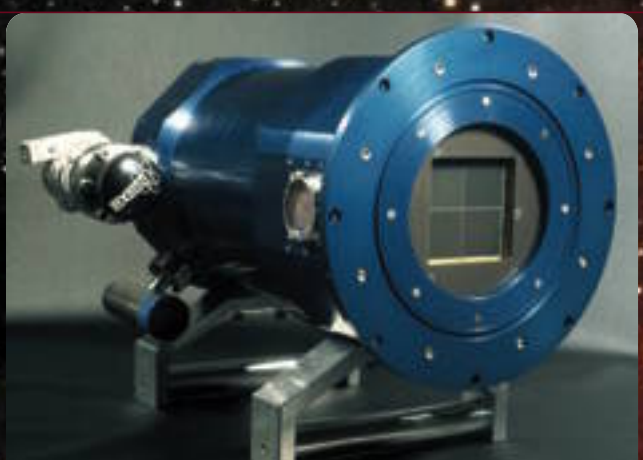
Initially, a severe drawback was the reduction in field of view: A photographic plate covered almost a full square degree on the sky, while the first astronomical CCD (measuring 100x100 pixels) covered less than 1 percent of that area. Astronomers adapted their scientific programs to make the best out of the small viewing field, and fortunately, by the early 1990s, CCDs up to 2,048x2,048 pixels were available. However, the physical size of these CCDs was reaching the limit of the support on which semiconductors are built. A silicon wafer at that time had a diameter of only 4 inches (6 inches is the standard today), a far cry from the required 13 inches that would be needed to create a detector covering the entire field of view of the CFHT. The only way to achieve a larger size was to build a mosaic of several large detectors packed tightly together to minimize the dead space between them.

In 1994, the first CCD mosaic camera installed at the CFHT prime focus (where all the light from the primary mirror is reflected) was MOCAM, a 16-million-pixel mosaic made of four 2,048x2,048 pixel CCDs. It was quickly followed in 1995 by the



THE CANADA-FRANCE-HAWAII TELESCOPE sits 13,800 feet (4,200 meters) above sea level, atop the dormant volcano Mauna Kea in Hawaii. The telescope is a 142-inch (3.6-meter) reflector that creates beautiful images of astronomical objects.

STAR-FORMATION REGION IC 1396 in Cepheus the King is an emission nebula — a huge cloud of high-temperature gas warmed by newly born stars. Hydrogen, the most abundant element in the universe, glows red when heated by hot stars. The dark foreground is a cooler region of dust and gas.



MOCAM, a camera that went into operation in 1994, was the first CCD mosaic camera installed at the prime focus of the CFHT. Images obtained by MOCAM contain 16 million pixels formed by an array of four 2,048x2,048 CCD chips.

THE CURRENT RECORD HOLDER for high-resolution CCD cameras is the CFHT's MegaCam, put into operation in 2003. Its array, shown here, consists of forty 2,048x4,612 CCD chips, for a staggering total of 350 million pixels.

University of Hawaii's UH8K, an 8,192x8,192-pixel mosaic made of eight 2,048x4,096 pixel CCDs, totaling a staggering 64 million pixels. CFHT and the University of Hawaii then combined their efforts and built a more refined camera with higher quality detectors, and even more pixels. The CFH12K, a 100-million-pixel mosaic, saw first light on the telescope in 1999.

Taking lessons from these successes — and in order to keep the CFHT scientifically competitive with its mirror of only 142 inches (3.6 meters) in the era of large telescopes with apertures more than twice as large — high-resolution, wide-field imaging was identified as the best niche for the CFHT.

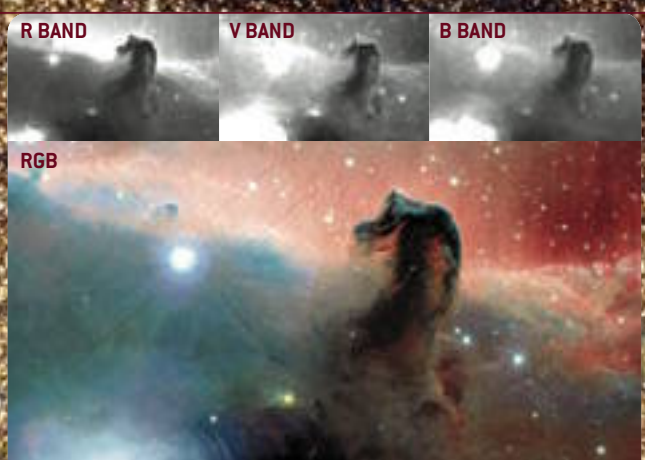
Today, MegaPrime, the newest wide-field imaging facility, includes a major upgrade of the telescope. The diameter of the field of view was increased from 1° to 1.4°. Also, astronomers installed the largest astronomical CCD mosaic ever built — MegaCam, which consists of forty 2,048x4,612-pixel CCDs (350 million pixels total). This array offers a full square degree field of view with ultra-fine resolution optimized to take advantage of the excellent sky conditions offered by Mauna Kea.

Sampling the colors

The sheer beauty of a nebula or a galaxy remains the best way for scientists to reach out to the public to convey information about our universe. However, making a harmonious color image is not a straightforward process. For the longest time, due to a lack of proper attention to collecting data in other wavelengths, astronomical images often were displayed in false-color mode. In such cases, colors were representative of intensities, not of intrinsic color. And, as previously mentioned, the detectors were small and provided coarse resolution.

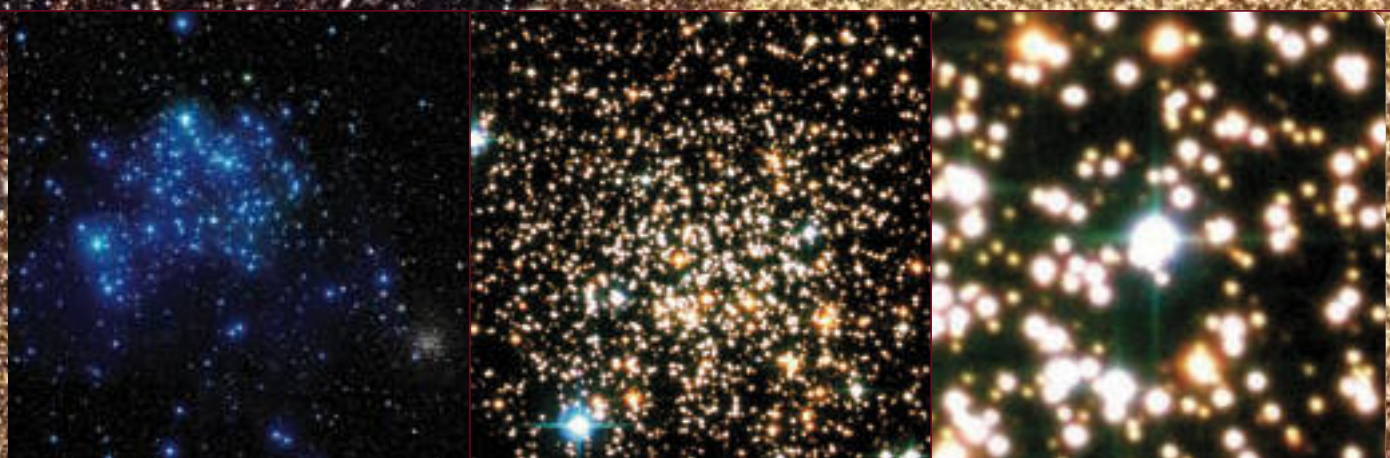
Creating a beautiful astronomical image means first and foremost achieving high resolution, and for that, you must have lots of pixels. For the colors, a three-color approach is best because it matches the way color documents are represented in the media. The best approach is to obtain three images in three colors. Because CCD detectors are monochromatic, three separate exposures are necessary to produce a full-color (RGB, or red/green/blue) image. Astronomers use a standard set of filters for these exposures, designated U (ultraviolet), B (blue), V (visual), R (red), I (infrared), and Z (long-wavelength infrared). From these, the colors red, green, and blue may be derived. Redder filters are not as interesting as bluer ones because the absorption by dust is weaker and creates less contrast in the image. Therefore, the U or B filter is mandatory to reproduce the blue color. Hydrogen-alpha (Hα) radiation is a prominent feature in the universe, falling at a wavelength of 656.28 nanometers, right in the red domain; hence Hα emissions ought to be represented by the red channel to obtain a "true color" (close to reality) image. This leaves the V filter for the green channel. The best combinations of filters to obtain the most lifelike RGB image, therefore, are R-V-B or R-V-U.

Jean-Charles Cuillandre *is an astronomer at the Canada-France-Hawaii Telescope atop Mauna Kea in Hawaii. His field of expertise spans the various technologies associated with wide-field astronomical data gathering and analysis.*



CREATING A "TRUE COLOR" IMAGE, here of the Horsehead Nebula in Orion, involves combining data taken through three individual filters. The R band, V band, and B band filters in the CFHT set accurately reproduce the colors in a standard RGB image.

THE MOOSE NEBULA, named by the author because of its shape, is a large obscuring nebula — a complex of dust and gas — that gives rise to the remarkable silhouette observed here. The foreground dust blocks the light from background stars, giving the impression of a hole in the star field.



OPEN CLUSTERS M35 AND NGC 2158 IN GEMINI were imaged by the CFHT's MegaCam. *Left*, The wide field of the CCD camera easily captured both clusters. Although shown in the same image, these clusters lie at very different distances from Earth. M35 is only 2,800 light-years away from us, while NGC 2158 lies six times more distant. *Center*, The high resolution of the image allows individual stars in NGC 2158 to be separated from one another with ease. *Right*, Zooming in even closer on NGC 2158 shows the real-pixel resolution of the CFHT's MegaCam.

Mosaic data handling

When MOCAM became operational in 1994, standard image-analysis tools proved inadequate for reducing and analyzing the 16-million-pixel images. So dedicated software was developed, and over the years, it's been upgraded. At CFHT, this software handles large data sets from mosaic cameras to produce processed frames for scientific analysis with all the signatures of the instrument removed.

The process of creating such a scientific frame is interesting. First, the data have any information related to a specific detector removed. Then, the typical corrections used for CCD images are applied, followed by an additive sky-effects correction. At this point, the image looks like one taken from a unique detector, but there are many blemishes still present: gaps caused by spaces between the CCDs, dark spots caused by cosmetic defects on the surface of the CCDs that are not sensitive to light, white spots on the image caused by cosmic rays spraying the detectors during the exposure, and lines across the image caused by the occasional passing artificial satellite.

To remove these blemishes and build a contiguous image of the sky, the areas missed or contaminated in the first frame must be recovered. At least four extra images are taken to accomplish this. With 360 million pixels per image, the total quantity of data per color reaches 3.5 gigabytes. Each image is then mapped into a larger, 19,000x19,000-pixel frame that respects the relative positioning, angle, and optical-distortion effect of all the CCDs in the mosaic. The data present in the five images are then simultaneously processed to build a single, final image. This is the one scientists will use to extract crucial information on shape, intensity, and other features of the astronomical objects captured in the image.

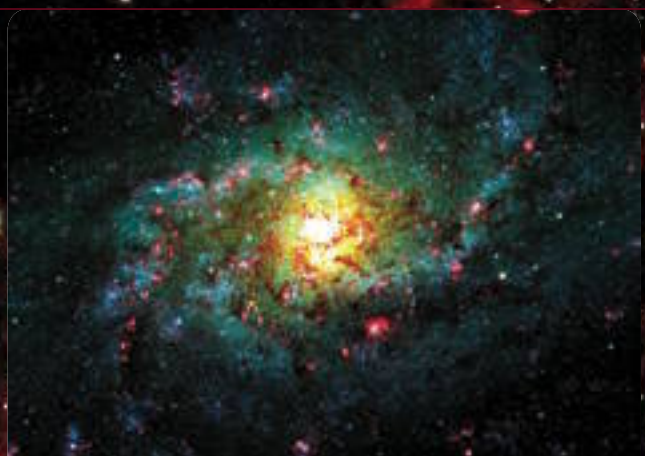
Color image creation process

The final steps used to create a beautiful, color image based on three independent color channels require some reframing of the image in order to get a more visually attractive result. Reframing matches the scale of the object to the fixed field of view of the telescope through which the image was made.

Combining the three colors to produce the final RGB image is a subjective and subtle, interactive process. A good starting point is to get the stars to appear white because the majority of them are similar to the Sun and, therefore, should present a yellowish-white color.

In the end, to get the best visual impact, most astronomical images require a bit of extra tuning in order to increase contrast and color saturation. CFHT has joined forces with the Italian scientific magazine *Coelum* in order to distribute final images that will capture the attention of the general public. While the colors and contrasts may show a slight departure from the "true color" paradigm, the end result is always well received by the public and the media. Because imagers follow this careful procedure, all images from the CFHT have great scientific value and are beautiful to look at as well. A

To learn more about the beautiful colors in CCD images, visit www.astronomy.com/toc

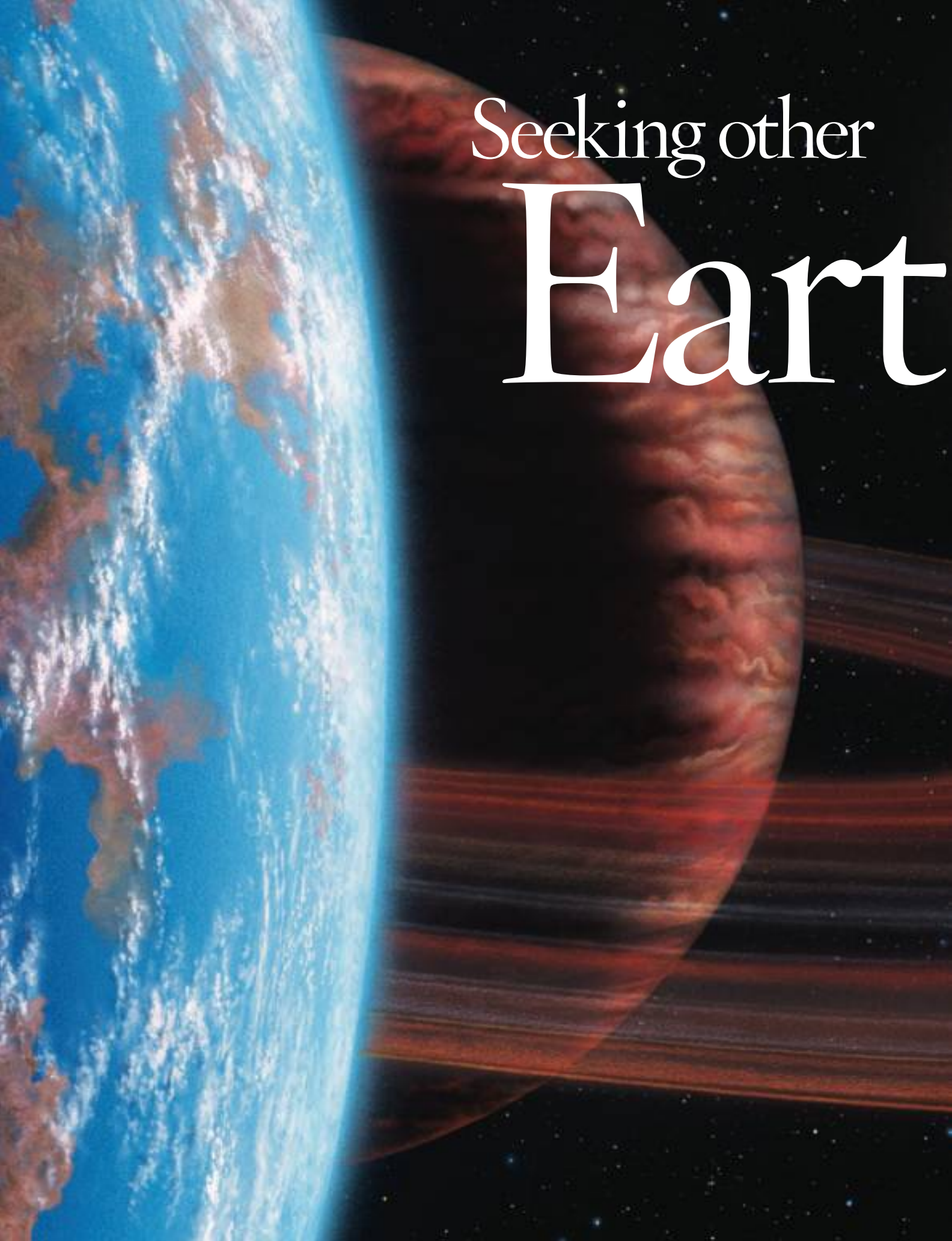


THE PINWHEEL GALAXY (M33) in Triangulum is one of our nearest galactic neighbors. M33 lies 3 million light-years from Earth and is a member of the Local Group of galaxies. Reddish areas visible in this image are star-formation regions.

SUPERNOVA REMNANT IC 443 lies 5,000 light-years away from Earth. Images like this one have helped astronomers determine when the star that formed this remnant exploded. IC 443 is approximately a thousand years old and the gas is expanding outward at a speed of several hundred miles per second.

THE DUMBBELL NEBULA (M27) in Vulpecula is well known to amateur astronomers. This image shows the field of view provided by the CFH12K CCD camera. The original image contains 100 million pixels, so astronomers have plenty of data to work with.

THE ORION NEBULA (M42) can be glimpsed from a dark location without optical aid as a fuzzy "star" — but not like this. High-resolution optics, long exposures, and careful image processing are required to show this star-forming region at its best.


Seeking other
Eart

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More than 120 extrasolar planets have been discovered, mostly gas giants. But what everyone *really* wants to find are "exo-Earths" orbiting other stars. Any day now, say the astronomers. /// BY ROBERT ZIMMERMAN

In 2001, a team of astronomers from Poland aimed the 1.3-meter Warsaw Telescope at the Las Campanas Observatory in Chile toward the center of the Milky Way. For 32 nights, they carefully recorded the faint light from 52,000 of more than 5 million stars in their field of view. Their goal: find planets.

With the light from so many stars, one stood out as unique. Despite the star's location 5,000 light-years away with an apparent magnitude of only 16.6, the scientists were able to discern a faint drop in the star's brightness. It lasted just 108 minutes and repeated every 1.2 days.

Although they weren't sure, the astronomers suspected they were seeing a planet as it traveled across its star.

Then another team of astronomers took a second look, using Doppler-shift techniques with the 10-meter Keck I telescope on Mauna Kea, Hawaii. In January 2003, they confirmed the detection, announcing that this ebb in brightness was caused by a Jupiter-size planet.

It was the first discovery of an extrasolar planet by the direct observation of a transit. Further analysis determined that the planet was a gas giant weighing only slightly less than Jupiter but having a diameter 30 percent greater.

More remarkably, the planet's 1.2-day orbit circled the star so tightly, at an average distance of about 2 million miles, that the temperature of its outer atmosphere was thought to hover around 3,000° Fahrenheit, making it almost as hot as the surface of many stars.

The new planet, inelegantly dubbed OGLE-TR-56b, joined the more than 120 other extrasolar planets discovered over the last nine years. In that time, the menagerie of planets has grown to include one planet 17 times more massive than Jupiter, and another only a little more than a tenth of Jupiter's mass. It includes planets in orbits nearly as short as OGLE-TR-56b's to as long as almost 15 years — and planets in orbits ranging from virtual perfect circles to ones as eccentric as the paths of comets.

Planets have been found orbiting binary stars. Planets have been found orbiting pulsars. Some planets orbit so close to their stars that the heat and stellar wind is literally causing the planet to evaporate slowly.

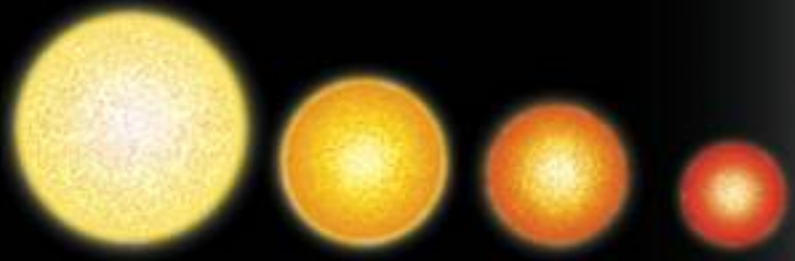
Yet despite a now-lengthy list of discoveries, the Holy Grail of extrasolar planet research remains out of reach. Of the 107 known solar systems, *not one* resembles our own, even approximately. In fact, the very existence of earthlike terrestrial planets in most of these newly discovered solar systems is impossible. So it would seem that habitable planets like our own are rare and very unusual.

Nonetheless, after almost a decade of discovery, astronomers who specialize in this field have reached a far different

EXTRASOLAR PLANETS are becoming routine to find, but none of the systems discovered so far include terrestrial-size planets. Locating a planet with earthlike characteristics — an "exo-Earth," perhaps with life — would be a tremendously important discovery. LYNETTE COOK

How to find exo-Earths

Check out stars more massive than the Sun



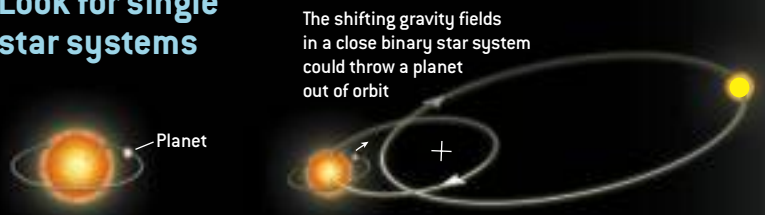
F-type stars
Planets: about 10% chance
1.3 to 1.5 solar masses

G-type stars (Sun)
Planets: about 7% chance
1 solar mass

K-type stars
Planets: 3 to 4% chance
0.3 to 0.7 solar mass

M-type stars
Planets: very unlikely
0.1 to 0.3 solar mass

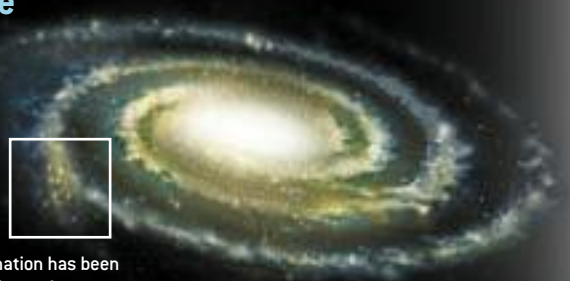
Look for single star systems



Single star system
Planets: possibly 100% chance

Binary star system
Planets: unlikely — orbits too unstable

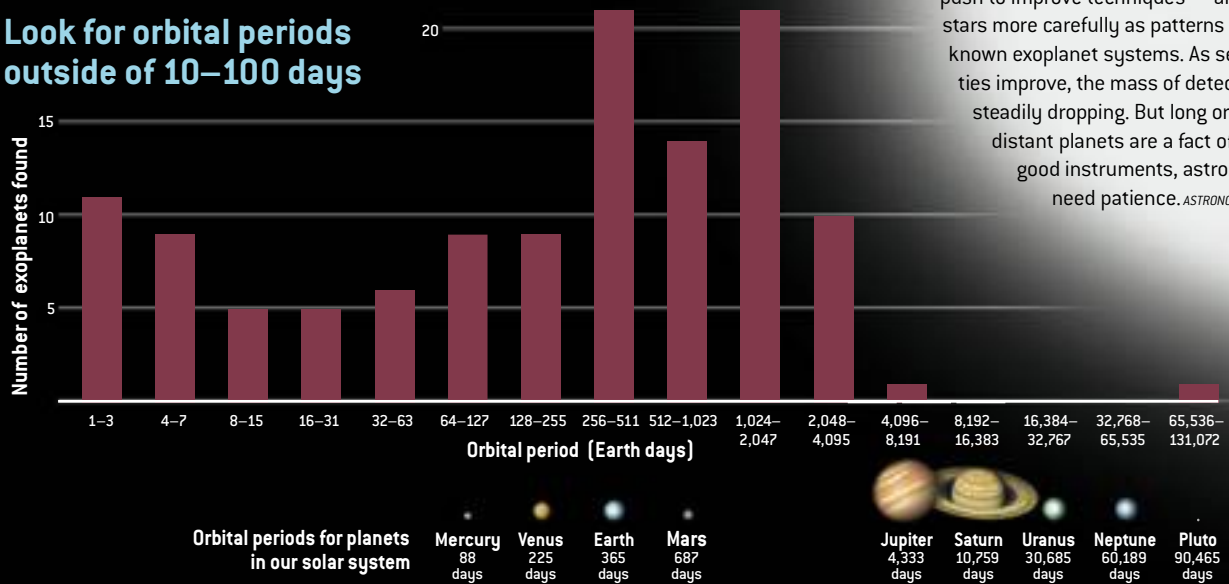
Search areas where stars have a high metallicity



Arms of a spiral galaxy
Planets: 20–30% chance

In the galactic arms, star formation has been going on for a long time, building up heavy elements to make planets.

Look for orbital periods outside of 10–100 days



Orbital periods for planets in our solar system

Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
88 days	225 days	365 days	687 days	4,333 days	10,759 days	30,685 days	60,189 days	90,465 days

conclusion. As they see it, a close look at the data suggests earthlike planets might not be unusual at all. Solar systems like our own can exist, they say, although they will not be scattered randomly throughout the galaxy. Moreover, only certain kinds of stars are likely to have planets, and of these, only a percentage can have planets like Earth, placed where life can prosper.

In other words, discoveries like OGLE-TR-56b not only show that today's extrasolar planet hunters have an increasing variety of amazing tools to look for planets, they also are giving scientists the necessary knowledge for determining exactly where to look. Based on these facts, exoplanet research should become very exciting in the next few years.

No Earths?

The first extrasolar planet discovered around an ordinary star, 51 Pegasi b, was a strange and unexpected revelation. A gas-giant planet more massive than Saturn, 51 Peg b orbits its star every 4.2 days at a distance of only 4.8 million miles. Considering that Mercury circles the Sun at 36 million miles every 88 days, the new planet was clearly in a toasty orbit.

Moreover, according to all theories then accepted about the formation and structure of solar systems, the planet should not exist. Gas giants were supposed to form in the chilly outback of a solar system and stay there. For a gas giant to coalesce this close to its star was supposedly impossible because the star's heat would destroy the lighter gases before they had time to

FINDING EARTHLIKE PLANETS involves a constant push to improve techniques — and targeting stars more carefully as patterns emerge among known exoplanet systems. As search sensitivities improve, the mass of detected planets is steadily dropping. But long orbital periods for distant planets are a fact of nature. Besides good instruments, astronomers also need patience. *ASTRONOMY:* ROEN KELLY

assemble into a planet. What's worse, a gas giant in the inner part of a solar system would likely prevent the birth of any earthlike planets by its powerful gravity.

Nor was 51 Peg b alone. By 2000, scientists had discovered more than a dozen new planets, the majority having orbits closer to their star than Venus is to the Sun. Half had orbits of less than a month, and all were gas giants with masses ranging from 0.4 to 11 Jupiter masses.

Other early research was equally depressing. In 1999, a team of scientists used the Hubble Space Telescope to survey globular cluster 47 Tucanae for planets.

Smaller planets continue to be discovered. And as they join the list, the average planet size keeps falling and the average orbital distance keeps growing. At this point, hot Jupiters compose a decreasing percentage of all extrasolar planets. Also, the planet count seems to be increasing as astronomers' techniques inventory more thoroughly orbital distances of 1 astronomical unit (AU) or greater. Hot Jupiters are relative exceptions, not the rule.

Moreover, the growing catalog of extrasolar planets has revealed interesting patterns, some of which astronomers do not yet understand. For example, relatively few planets seem to have orbital periods of 10 to 100 days. Furthermore, in orbits greater than 100 days, very few planets have less than three-quarters of Jupiter's mass. Why these patterns exist is unclear.

The most intriguing discovery emerging from the data concerns the kinds of stars capable of producing planets. It appears, for example, that the more massive a star, the more likely it will have planets. Type M dwarf stars, with masses from a tenth to a third of the Sun's mass, almost never have planets. K stars, with masses of 30 to 70 percent of the Sun's, have planets about 3 to 4 percent of the time, while G stars, like our Sun, have planets some 7 percent of the time. And F stars, 30 to 50 percent more massive than the Sun, have planets about 10 percent of the time.

Furthermore, single stars seem to form planets more often than binary systems do. "Binaries, and in particular close binaries, probably don't permit any planetary systems to survive," notes Geoffrey Marcy of the University of California, Berkeley and one of the lead scientists in the California & Carnegie Planet Search. "Such stellar companions would gravitationally slingshot any of the planets right out of the system." Marcy believes that perhaps all single stars will prove to have planets.

Finally, a star's composition seems important. Right from the beginning, scientists noticed that extrasolar planets are more likely to orbit stars that are at least as rich in complex atoms as our Sun. These heavier atoms, which astronomers broadly term "metals," are the result of several episodes of star formation, with each new generation of stars adding its own heavier atoms to the star-making mix.

Recent exoplanet discoveries have confirmed that the greater a star's metallicity, the better its chances to have planets. In our neighborhood of the Milky Way, 20 to 30 percent of Sun-like stars with large metallicities are known to have planets. And that's after only a decade of study; given time and more discoveries, the percentage should rise significantly.

> "Binaries, and in particular close binaries, probably don't permit any planetary systems to survive." – GEOFF MARCY, UNIVERSITY OF CALIFORNIA, BERKELEY

Based on their sample of 34,000 stars, they figured on spotting approximately 15 to 20 planets in their search.

Instead, they found none.

"In a global sense," noted Ron Gilliland, lead scientist on the survey, "the result for 47 Tuc indicated that the existence of planets was less likely than we might otherwise have expected."

Better statistics

Despite the discouraging results, astronomers were not worried. The Doppler detection techniques initially used in searches strongly favor the discovery of large planets (greater than 1 Jupiter mass) orbiting close to their stars (with orbits shorter than a year). Therefore, "hot Jupiters" like 51 Peg b were the most likely planets to be found first.

Subsequent discoveries have given hot Jupiters (or "roasters," as one scientist calls them) less significance. Almost all the known nearby F-, G-, K-, and M-type single stars — that is, those most like our Sun — have been studied for periods ranging from 5 to 10 years. It's safe to say that practically all the hot Jupiters orbiting these stars have been found by now.

Maybe the lack of planets in globular cluster 47 Tucanae was not so surprising after all. The constant interaction of the cluster's closely packed stars would likely rip any planets from their stars, setting them adrift within the cluster. "Planets do not like very crowded environments," says Dimitar Sasselov of the Harvard-Smithsonian Center for Astrophysics.

Second, and possibly more important, globular clusters are old. They formed back when the Milky Way did and are full of first-generation stars deficient in metals. Compared to the Sun, 47 Tucanae has less than a third the metallicity. As Gilliland notes today, "Taken what we know now about metallicity and planet formation, it isn't really surprising that we found no planets in the cluster."

Globulars, however, should not be presumed to be entirely planet-free. An ancient gas-giant planet has been found orbiting a pulsar-and-white-dwarf binary in globular cluster M4 (see "Genesis planet," *Astronomy*, June 2004). But this planet's unusual history — normal birth 13 billion years ago followed by ages of gravitational ping-pong — make it rare, if not actually unique.

Better theories

No longer chained to a belief that solar systems have to resemble our own, theorists began to figure out why these newly discovered solar systems look as they do.

Robert Zimmerman *is a regular contributor to* Astronomy. *His most recent book is* Leaving Earth: Space Stations, Rival Superpowers, and the Quest For Interplanetary Travel *(Joseph Henry Press, 2003).*

THE KEPLER MISSION will be launched in 2007 by NASA to monitor the brightness of more than 100,000 stars. Kepler will look for the faint dimming of stars caused as Earth-size planets cross their faces. NASA

LOOKING FOR TINY WIGGLES in stars' positions is the job of the Space Interferometry Mission, due for launch by NASA in 2009. Cyclic changes in a star's position betray bodies orbiting it. NASA

SEEKING OTHER EARTHS is the mission for NASA's two-part Terrestrial Planet Finder. The first (top), dubbed TPF-C, will launch around 2014. It will hunt planets in visible light by blocking the direct glare from stars. The mission's second half, TPF-I (bottom), will launch before 2020. It will use infrared interferometry to study planets found by TPF-C and others. The European Space Agency's planned Darwin mission resembles TPF-I. NASA

In 1996, astrophysicists Douglas Lin, Peter Bodenheimer, and Derek Richardson described how the interaction between a new gas-giant planet and the dust disk from which it formed would drive a planet like 51 Pegasi b inward. The mass of the disk would drag on the planet's orbital velocity, causing the orbit to shrink.

The orbit would stabilize only when the dust disk vanished, either blown away by the star's radiation or absorbed by new planets. The point when that happened would set the giant planet's final orbit. If it happened quickly, the gas giant would resemble Jupiter, orbiting far enough away that terrestrial planets could form closer to the star. "That's most likely what happened in our solar system," notes Sasselov.

If the disk took longer to vanish, the planet would migrate inward until it became a hot Jupiter. In some scenarios, the gas giant was absorbed by the star.

More rigorous computer simulations by others have since shown that hot Jupiters can form close to the star. Scientists at the Tokyo Institute of Technology found that because a planetary disk is denser within 1 AU (and orbits are shorter), the accretion time for a gas giant could be as brief as a thousand years. This is easily fast enough to build up a planet before the star ignites and its heat and stellar wind blow away the dust.

Many mysteries still

Despite their increasing knowledge, planet hunters are far from content about the state of their field. Although existing theories can explain things like the migration of hot Jupiters, for now, as Ron Gilliland notes, "We don't have an excellent predictive theory of planet formation."

The favored theory of planetary formation, dubbed core accretion, says that as a rotating planetary disk forms around a young star, collisions in the disk cause dust particles to stick together. These build small planetesimals several miles across; some of these will become cores on which material will accrete to form planets.

In the inner solar system, the process can make planets in less than 100,000 years, far less than the million-year life span of a planetary disk. The process can also make planets with enriched metallicities as seen in our own solar system, where the planets have proportions of heavy atoms several times greater than the Sun's.

Core accretion, however, has problems creating gas giants fast enough. In fact, it has trouble producing these planets in less than 100 billion years, far longer than the age of the universe.

Another theory, less popular, says that gravitational instabilities cause dense clumps to form as the planetary disk collapses, out of which planets consolidate. While this theory can make gas giants in distant orbits within the necessary time, it can't produce planets with the high metallicities seen in the solar system. Instead, the planets mimic the Sun, with compositional ratios about the same.

More important, neither theory can explain how almost all known exoplanets have orbits far more eccentric than the planets in our own solar system. "We actually don't understand yet the origin of so many highly eccentric orbits," says Sasselov. "It's clear that it has something to do with interactions between the planets and the disks, but it is not clear how."

Maybe the real issue is why the planets in our solar system have such perfectly circular orbits. "Therein lies the key question," says Marcy. "Is our own solar system a common type or some quirk?"

Then consider OGLE-TR-56b, the first extrasolar planet discovered as it transited across the face of its star. According to the Doppler surveys, a lot of planets have orbits ranging from 3 to 5 days, but none have shorter orbits. This led astronomers to assume that 3 days was the shortest natural orbit for a planet.

Then OGLE-TR-56b was discovered, circling its star every 1.2 days.

These inconsistencies and questions point out an essential fact. Surveys are still far from complete for a good reason: time. In our own solar system, the orbits of Jupiter and Saturn last 12 and 29.5 years, respectively. For astronomers to discover either planet using Doppler techniques would require a minimum of 24 and 60 years of observations, respectively.

Scientists have been searching with sufficient accuracy to spot a Jupiter for only about a decade, and even that accuracy is still inadequate to see a Saturn. In fact, with today's Doppler equipment, astronomers could look for a century and never detect Saturn. To discover planets this size and smaller, far from some other Sun, will require markedly better equipment and searches lasting literally for decades.

GAS-GIANT GUARDIANS can keep an inner solar system relatively free of impacts from comets and debris. FROM *FARAWAY WORLDS* BY PAUL HALPERN, ILLUSTRATED BY LYNETTE COOK

Where to look

Nonetheless, after almost ten years of discoveries, astronomers can now start drawing some conclusions.

First exoplanets lie in younger, more metal-rich regions of spiral galaxies. Notwithstanding the planet in M4, globular clusters make poor hunting grounds. Planets are more likely in the galactic arms, where star-making has proceeded for ages. Exoplanets also will be found in the quieter regions of those arms, where fewer massive stars can burn off planetary disks before planets form — and where few other stars interfere closely enough to throw planets into interstellar space.

With this in mind, the Hubble Space Telescope was recently used to search for transits in the galactic bulge. Similar to the 47 Tucanae observations but looking in a better place, this new survey is expected to find between 50 to 100 planets.

Next, astronomers should focus on single stars, either G-type like the Sun or F stars that are more massive. Present surveys suggest at least 10 percent of these stars have planets — and maybe all might prove to contain planetary systems once detection techniques improve.

In this regard, the California & Carnegie Planet Search is building a 2.4-meter telescope for Doppler observations three times more sensitive than anything today. If all goes as planned, this instrument will examine approximately 100 nearby stars per year and should be able to spot planets as small as 10 Earth masses within orbits of 1 AU.

Finally, astronomers need to look for a long time. NASA has plans to build several different planet-finders of much greater resolution. The Kepler mission, scheduled for launch in 2007, will hunt for transits of Earth-size planets by looking at more than 100,000 stars continuously. Following this, in 2009 the Space Interferometry Mission will be able to detect the presence of Earth-size planets in orbit around the nearest hundred or so stars. Last, in 2014, will come the two-part Terrestrial Planet Finder, possibly the most ambitious mission of all. It is designed to detect and study the feeble light of any earthlike planets within 45 light-years.

No other Earths are known at present, but the most exciting part of the hunt is about to begin. Stay tuned for big news.

For more on extrasolar planet searches, see www.astronomy.com/toc

{ INSTRUMENTATION }

Warm and not so fuzz

Planets, stars, nebulae, and galaxies — early returns from the Spitzer Space Telescope show the infrared observatory tackling them all with gusto. /// BY BRUCE DORMINEY

Water vapor, carbon dioxide, ozone, and methane have long wreaked havoc on astronomers' efforts to see infrared radiation coming from the cosmos. Observers can peer through only a few windows in Earth's atmosphere at the lower end of the infrared spectrum, beginning at wavelengths just longer than those at the limits of our own eyesight. The best ground-based infrared observatories are positioned above much of the opaque atmospheric curtain, in very dry, high deserts, such as Chile's Atacama, or atop Hawaii's Mauna Kea, the dormant volcano cum astronomical reserve.

Infrared astronomers seeking to circumvent our atmosphere have used balloon-borne telescopes, high-flying observatories, such as the Kuiper Airborne Observatory, and even space itself as viewing platforms. Early space missions, such as NASA's Infrared Astronomical Satellite (IRAS) and the European Space Agency's Infrared Space Observatory (ISO), tantalized astronomers, but NASA just rewrote the playbook with the successful August 2003 launch of the last of its four Great Observatories. This one-ton, $765-million jewel in the crown has been renamed the Spitzer Space Telescope (SST) in honor of the late Lyman Spitzer, Jr., the astronomer who, in 1946, first proposed placing a telescope in space.

It's been a stunning success. Early observations using the telescope's 0.85-meter Ritchey-Chrétien optics have left many astronomers gaping at the detail and clarity of the images, as well as the observatory's ability to pierce heretofore hidden regions of the cosmos. Although some glitches have turned up in one of the telescope's imaging arrays, Michael Bicay, assistant director of the Spitzer Science Center in Pasadena, California, says no science has been "left on the cutting-room floor" as a result of its on-orbit

STAR-FORMING REGION D21 (at far right) harbors a young star 100,000 times brighter than the Sun. A shroud of dust hides the region in visible light, letting through only one photon of every 10,000 trillion trillion trillion, but Spitzer penetrates it with no problem. NASA/JPL-CALTECH/A. MARSTON (ESTEC/ESA); INSET: NASA

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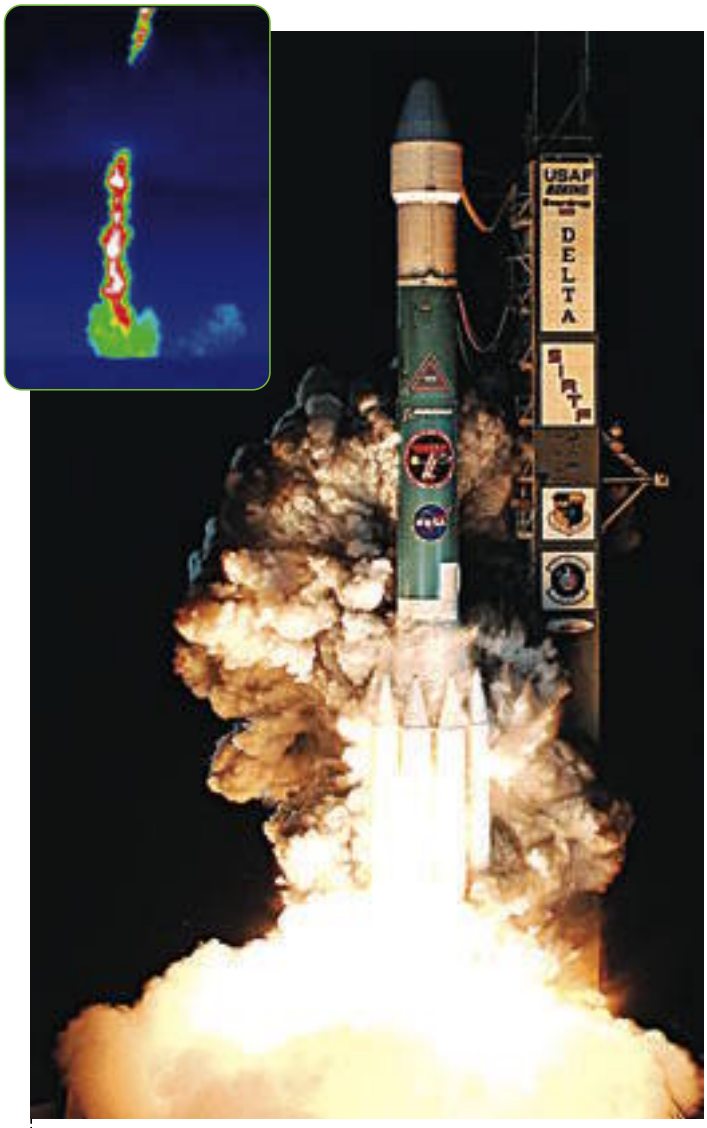


SPITZER ROCKETED INTO SPACE on August 25, 2003, aboard a Delta-II. NASA **THE TELESCOPE OBSERVES INFRARED LIGHT,** so it seems fitting that NASA also recorded the observatory's launch in the infrared (inset). NASA/JPL-CALTECH

HOWLING WINDS and high-energy radiation sculpt this stellar nursery, a cloud of gas and dust embedded in the much larger nebula IC 1396 in the constellation Cepheus. NASA/JPL-CALTECH/W. REACH (SSC/CALTECH)

ELEGANT SPIRAL ARMS populated by clumpy, star-forming clouds and warm dust curve out from the central bulge of the bright spiral galaxy M81 in northern Ursa Major. NASA/JPL-CALTECH/S. WILLNER (HARVARD-SMITHSONIAN CfA)

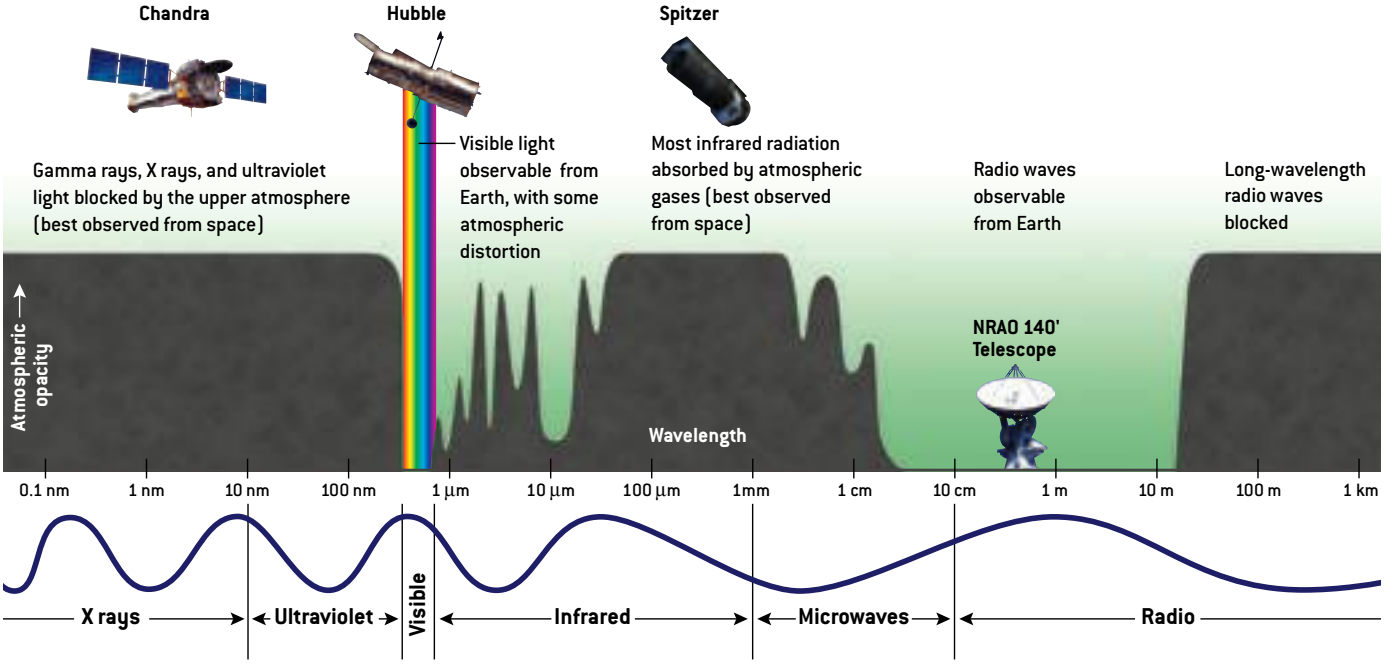
performance. All three of Spitzer's observing instruments are functioning normally, and the telescope's ability to point is better than anticipated. Moreover, the latest estimates give the scope a life span of more than five and a half years.

When the mission is done, astronomers expect that Spitzer and its three instruments — the Infrared Array Camera (IRAC), the Multiband Imaging Photometer for Spitzer (MIPS), and the Infrared Spectrograph (IRS) — will have detected at least a million new galaxies. Although that's just a drop in the bucket given the observable universe's estimated 100 billion galaxies, Spitzer's crucial sampling will provide a better understanding of galaxy formation and evolution. It also will yield new details on the disk and star-forming regions in our own Milky Way Galaxy, as well as in dozens of other well-known spiral galaxies, such as the Andromeda Galaxy (M31) and M81. "We can legitimately argue that Spitzer is ten to hundreds of times more sensitive than the ISO mission," says Bicay. "We can see things that are ten to hundreds of times fainter for a given exposure time."

In its Earth-trailing solar orbit, Spitzer drifts away from its home planet at a rate of about 9.3 million miles per year. This places the observatory in "deep space" — where the ambient temperature remains between 30 and 40 kelvins (30° to 40° Celsius above absolute zero) — and saves the precious cryogenic liquid helium that cools the telescope to its optimal operating temperature of 5.5 kelvins. If Spitzer orbited Earth instead, it would be bathed in temperatures exceeding 250 kelvins.

The infrared part of the electromagnetic spectrum ranges from wavelengths of about 1 to 200 micrometers (one micrometer is one-thousandth of a millimeter), with the shortest wavelengths belonging to the near-infrared and the longest to the far-infrared. Spitzer observes at wavelengths between 3 and 180 micrometers. At any given time, Spitzer can view at least a third of the sky, but the Sun hamstrings its pointing — closer than 80° toward the Sun would damage the instruments; more than 120° away would cause the solar panels to receive too little sunlight, the source of the observatory's power.

Bruce Dorminey *is a France-based science journalist and author of the book* Distant Wanderers: The Search for Planets Beyond the Solar System *(Springer-Verlag, 2001).*



MOST INFRARED LIGHT, along with most other electromagnetic radiation, gets blocked by Earth's atmosphere before it reaches the ground. *ASTRONOMY:* ROEN KELLY

Even so, Spitzer has several clear views out of our galaxy and back into cosmic time. Such observations should allow theorists to better understand how the distant universe evolved to mesh with what we now observe in the local universe. Eighty years after Edwin Hubble recognized that many celestial nebulae were actually galaxies in their own right, we still don't know how galaxies form and evolve. Most of the money seems to be on the "bottom-up" scenario, in which fragments of galaxies formed when clouds of atomic hydrogen collapsed into rotating disks spun up by angular momentum. These gaseous disks turned into clouds of molecular hydrogen that gradually merged to form stars and create beautiful spiral galaxies like the Milky Way and Andromeda.

Spitzer will give us a better picture of how such large galaxies came together. As part of GOODS, the multi-spectrum Great Observatories Origins Deep Survey, Spitzer will do pencil-beam infrared surveys of very distant galaxies to determine their stellar populations, masses, and star-formation rates. "People once had a simple view that galaxies collapsed at some high redshift, formed all their stars, and then just sat there, passively evolving," says Mark Dickinson, an astronomer at the National Optical Astronomy Observatories in Tucson, Arizona, and leader of Spitzer's role in GOODS. "We hope to watch galaxies building up their mass with time, find out when they did it, and what drove that process. How much star formation happened during catastrophic mergers between galaxies and how much happened quiescently? We want to watch that process happen."

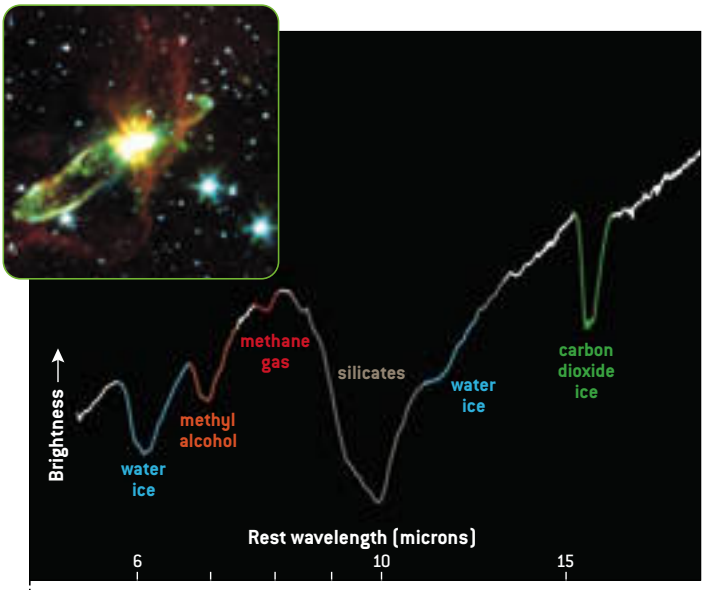
Observing two patches (one each in the northern and southern sky) totaling about 300 square arcminutes, Spitzer will look at an area about half the size of the Full Moon. But its gaze will head out to a redshift of 5, or more than 11 billion years ago, when the universe was only about 2.5 billion years old.

SWIRE, the Spitzer Wide-area Infrared Extragalactic survey, will map galactic structure over large volumes out to a redshift of 2.5, or about half the depth of GOODS. SWIRE will observe six separate fields adding up to 50 square degrees. The survey will trace the evolution of dusty, star-forming galaxies and active galactic nuclei as a function of their environment and plot where they lie within the universe's large-scale structure.

Efforts to determine the large-scale structure of the universe accurately remain in their infancy. The largest structures, superclusters, are collections of many thousands of galaxies spreading hundreds of millions of light-years across the curvature of space-time, not unlike a spider web stretching across the corner of a dark shed. The largest individual galaxy clusters, termed rich clusters, can contain thousands of galaxies, while small galaxy groups might contain only a few dozen. Our own Milky Way Galaxy belongs to the Local Group, a cluster of galaxies at the edge of the Virgo galaxy cluster, which, in turn, inhabits a supercluster of galaxies termed the Virgo supercluster.

"Large-scale structure is a fossilized imprint of how the overall texture of space-time was imprinted a fraction of a second after the Big Bang by slight fluctuations in temperature and density," says David Koo, an astronomer at the University of California, Santa Cruz's Lick Observatory. "The overall pattern doesn't change, but the threads of that pattern do change because on small scales they are affected by gravity. Over time, the threads of the cosmic web react with gravity and convert matter into stars and galaxies. The joints of where these threads meet is where the rich clusters will be."

Spitzer also will target nearer galaxies, studying 75 that mostly lie within the Virgo supercluster. The Spitzer Infrared Nearby Galaxies Survey (SINGS) is a multi-spectrum survey that runs the gamut of galaxy types. Scientists expect SINGS to help them understand the physical processes that create stars out of a galaxy's interstellar medium. "The star-formation rate varies by a factor of a million from one galaxy to the next," says Robert Kennicutt, an astronomer at the University of Arizona's Steward Observatory and SINGS principal investigator. "We are going to be able to calibrate measures of star-formation activity that we can apply to the distant universe. These nearby galaxies will provide us with libraries of galaxy spectra going all the way from X rays to radio."



SPITZER PENETRATED the dusty birth cocoon of Herbig-Haro 46/47 (inset), revealing a protostar that could end up resembling the Sun. **THE THICK DUST CLOUD** shows up in this Spitzer spectrum as a big dip caused by silicates. NASA/JPL-CALTECH/A. NORIEGA-CRESPO (SSC/CALTECH), H. KLINE (JPL)

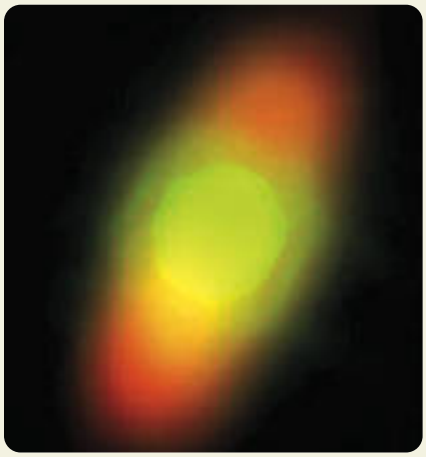
These observations, in turn, can be used to help theorists make sense of more exotic objects like ultraluminous infrared galaxies (ULIRGs), which emit 90 percent of their total energy in the infrared. Thought to be powered by intense bursts of star formation stimulated by colliding galaxies or central supermassive black holes, ULIRGs were detected first by IRAS. Spitzer should be able to find a hundred times as many of them over a wider range of redshifts.

Spitzer also will take more than a glimpse at the Milky Way Galaxy. The Galactic Legacy Infrared Mid-plane Survey Extraordinaire (GLIMPSE), a 240-square-degree mid-infrared survey of our galactic plane, will home in on roughly half (some 2,000) of the Milky Way's star-formation regions and take a census of all star types in the inner galaxy. GLIMPSE will catalog some 100 million sources lying within 2° of the galactic plane and between 10° and 70° of the galactic center. The survey excludes the galactic center, which is too bright for Spitzer's instruments to observe.

GLIMPSE even may resolve the long-debated galactic conundrum concerning how many spiral arms our galaxy possesses. While four is the most accepted number, galactic astronomers still regularly discuss the issue. "Pan across the galaxy and count the number of times you scan through a spiral arm," says Ed Churchwell, an astronomer at the University of Wisconsin in Madison and the GLIMPSE principal investigator. "Like an egg going through the body of a snake, the stellar density should go sky-high, allowing us to extrapolate how many spiral arms there are and where they lie."

The Milky Way's spiral arms remain full of active star-forming regions. Astronomers think these regions are fed largely by high-velocity clouds of intergalactic gas as well as gas from dwarf galaxies that our giant spiral cannibalizes as it plows through intergalactic space. Spitzer is surveying 30 square degrees in five different giant molecular clouds — Perseus, Ophiuchus, Lupus, Serpens, and Chamaeleon II — in addition to 120 smaller molecular clouds. The observatory already is taking the temperatures of such molecular clouds in an effort to get a better handle on their chemical compositions and understand the physical conditions

/// ON THE TRAIL OF PLANETS



A DUSTY DISK HINTS that a planetary system could be forming around the nearby star Fomalhaut. NASA/JPL-CALTECH/K. STAPELFELDT (JPL)

Spitzer also will try to answer some fundamental questions closer to home. How rare is our solar system? What percentage of stars have planetary systems that might harbor planets like our own? A significant percentage of the SST's observing time will go to such studies. Spitzer will survey 336 Sun-like stars within 500 light-years of Earth, all between 3 million and 3 billion years old, looking for both young circumstellar disks from which planets might form and the telltale signature of older planetary debris disks.

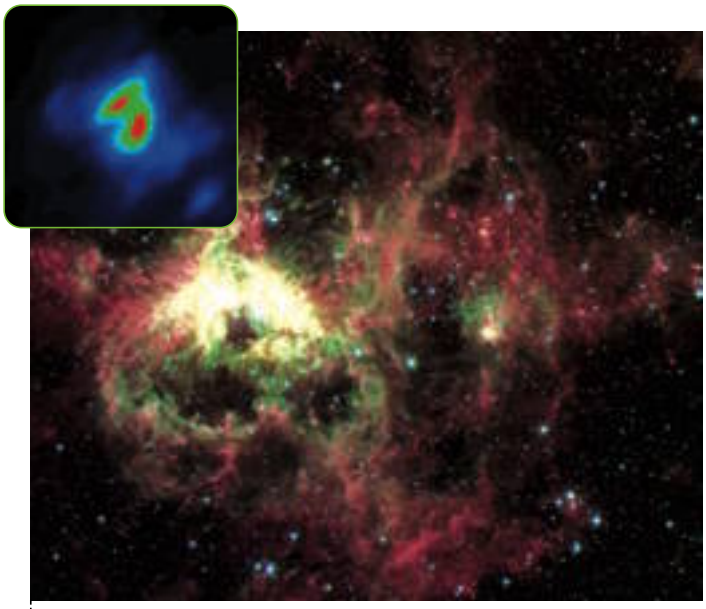
IRAS gave us the first clues that other stars form disks. It found disks around Beta Pictoris, Vega, and Fomalhaut, three fairly massive stars of spectral type A. However, A-type stars hardly would be the first place to look for habitable earthlike planets because these stars live fast and die young, quickly becoming unstable and leaving the hydrogen-burning main sequence phase of their lives.

Spitzer recently took the first-ever snapshot of Fomalhaut's inner disk, showing dusty debris left over from putative planet formation. From 25 light-years away, the planet (or planets) circling this 200-million-year-old star can't be picked out, but astronomers can infer its presence.

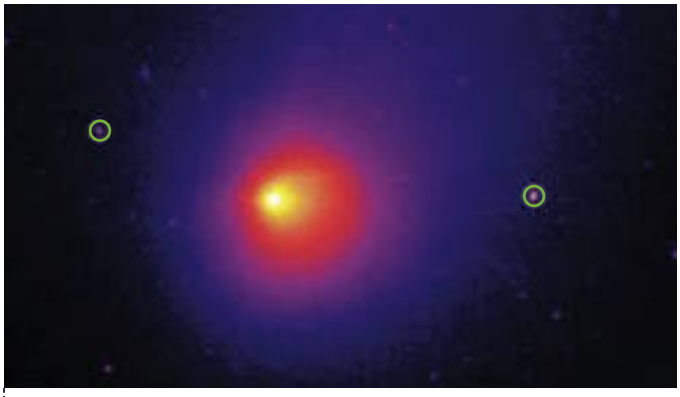
"Spitzer will extend the population of known disks to much fainter disks," says Charles Telesco, an astronomer at the University of Florida. "Those disks can be fainter for two reasons: because they are more distant and because they have less mass. Initially, you get this dense disk, which is the remnant dust of the formation of the star. That disk begins to form planets. Over time, this disk goes from being a primordial disk to a debris disk, as collisions between planets and asteroids create more dust."

Astronomers think planet formation occurs within the first 100 million years of a star's life, and a billion-year-old star with a dusty disk around it likely would indicate a continuous generation of dust. If there's a gap in the range of observed dust temperatures within the disk of such a star, the Spitzer team might infer the presence of a planet there.

"If you looked at our solar system from a great distance," says Steward Observatory astronomer Michael Meyer, "you would see a huge, inner, evacuated region between the asteroid belt and the Kuiper Belt. In 18 months, we hope to have a quick answer — and then in 3 years, a pretty good answer — about whether our solar system's disk evolution was common or rare for Sun-like stars."



THE TARANTULA, the largest star-forming region known, rules the infrared scene in the Large Magellanic Cloud. NASA/JPL-CALTECH/B. BRANDL (CORNELL AND LEIDEN) **IRAS VIEWED THE TARANTULA** (inset) in far less detail 20 years ago. IPAC, CALTECH/JPL



PERIODIC COMET Schwassmann-Wachmann 1 flares by five magnitudes during its frequent outbursts. Spitzer imaged two asteroids (circles) along with the comet. NASA/JPL-CALTECH/D. CRUIKSHANK (NASA AMES) AND J. STANSBERRY (ARIZONA)

NEW STARS WARM the dust grains in NGC 7129 in Cepheus, causing it to glow with a pinkish hue, while molecules of carbon monoxide produce the greenish color. NASA/JPL-CALTECH/T. MEGEATH (HARVARD-SMITHSONIAN CfA)

that create ripe environments for stellar nurseries. The closest of these is in the much-studied Orion Nebula (M42), which clearly is visible to the naked eye in the sword of Orion.

Jeremy Mould, director of the National Optical Astronomy Observatories, has been doing some follow-up ground-based observations of early Spitzer data taken from Henize 206, an immense star-forming region located outside the Milky Way in our companion galaxy, the Large Magellanic Cloud. "This complex portrays the whole story of stellar evolution, from formation and birth to supernova and death," says Mould. "These Spitzer images are fantastic and really show the embedded infrared sources, which are invisible at shorter wavelengths because they are wrapped in dust." Our own Sun likely formed in such a dust-covered cocoon.

Some 3,300 light-years away in the constellation Cepheus lies a rather small, young, star-forming region enveloped in a larger, rosebud-shaped gas nebula. Spitzer recently observed this region, NGC 7129, as part of a survey of about forty star clusters. NGC 7129 has 130 stars of almost every spectral type crowded in a region roughly 4 light-years across. All the while, the young stars in NGC 7129 and other typical clusters are pushing their way out of the dusty masses from which they were born.

"In a hundred million years, the Orion Nebula may look like the Pleiades open cluster," says Tom Megeath, an astronomer at the Harvard-Smithsonian Center for Astrophysics. "The Pleiades may have started with lots of hot stars and then those stars went supernova, causing the low-mass stars to fly out, leaving maybe only half. Chances are our Sun formed in a cluster like NGC 7129 or bigger. But you'd never be able to figure out where the Sun's siblings are. Once the mass is gone, the stars just start drifting away."

This is not unlike the Spitzer Space Telescope itself, which continues to drift slowly away from Earth. Fortunately, the Sun will survive far longer than Spitzer ever could. But if the observatory continues to perform as it has, astronomers will gain a much clearer understanding of how the Sun and Earth came to be — born from a cloud of gas and dust in a modest galaxy among billions of others spread throughout a vast universe. A

To witness the launch of the Spitzer Space Telescope in infrared light, visit www.astronomy.com/toc

BY MARTIN RATCLIFFE AND ALISTER LING

AUGUST 04

The view of the Milky Way in a star-studded sky highlights August nights, although the best sights this month should be of meteoric debris flaring to incandescence.

Perseids prime the pump

The grandeur of a star-filled sky, viewed on a balmy summer night under a dark country sky, leaves an indelible impression on anyone who sees it. Not coincidentally, our first wishes upon shooting stars often occurred on such back-country sojourns. From late July to late August, Earth sweeps up innumerable interplanetary dust particles and the atmosphere burns them into oblivion, creating silent streaks that slice across the sky.

The best time this year to seek such a grand vista is Wednesday night, August 11/12, the peak of the annual Perseid meteor shower. To see dozens — or perhaps hundreds — of meteors, your best strategy is to rest early, set an alarm for 1 A.M., then watch until dawn. Advances in understanding meteor dust trails have boosted confidence that an additional profusion of Perseids should be visible this year for Eastern Hemisphere observers.

THE SUMMER MILKY WAY dominates the August evening sky — as long as you get well away from the lights of the city. JOHN CHUMACK

Under a dark sky, the stars sometimes seem close enough to reach out and touch. But reality is far different — and much more interesting. Look toward the southeast on an August evening and you'll see what appears to be a steam cloud floating in front of the stars. That glow comes from billions of stars so far away you can't make them out individually. Like grains of sand on a beach, the stars combine into a smooth radiance when seen from a distance. The dark lane that courses through the middle — the "Great Rift" — does not represent a chasm empty of stars. It's actually an absorbing curtain of dark dust much closer to us than the glowing river we call the Milky Way.

The best nights to enjoy such views fall within a week or so of the August 15/16 New Moon, which conveniently includes the peak of the Perseid shower. The Moon begins the month just a day past full phase, rising around sunset and progressively later each succeeding night. By the night of the Perseid peak, the Moon rises after 2 A.M. local daylight time and appears only 12 percent lit, so it won't hinder the view much at all.

The week of the Perseids should be perfect as well for following two modestly bright comets in the evening sky: C/2001 Q4 (NEAT) and C/2003 K4 (LINEAR). Using binoculars, you will have an easy time finding Q4 near the bowl of the Big Dipper. We provide a finder chart on page 67 for the slightly brighter K4.

As luck would have it, the five planets bright enough to see easily with the naked eye have all but disappeared from the evening sky. The splendid spring lineup has slipped behind the Sun, leaving a lone "wanderer," Jupiter, dipping into the sunset glow. It masquerades as a distant plane's landing light during the first half of August. A low, difficult-to-see pairing with the waxing crescent Moon occurs on the evening of the 17th.

The two outer gas giants, Uranus and Neptune, rise near sunset and appear highest in the south around midnight. They both reach opposition in August, lying opposite the Sun in our sky and remaining visible all night. The blue-green glow of Uranus is easy to spot in binoculars, but you'll need a telescope to spy the subtle blue-gray shading of Neptune.

Brilliant Venus heralds the approaching dawn after an all-night observing session. It reaches the peak of this apparition in mid-August, when it lies farthest west of the Sun and appears highest in the morning sky.

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Finderscope	9x50	9x50	9x50
AC Adapter***	Included	Included	Included
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Fastar Compatible	Yes	No	No
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Resolution (Rayleigh)	.68 arcseconds	.59 arcseconds	.50 arcseconds	.39 arcseconds
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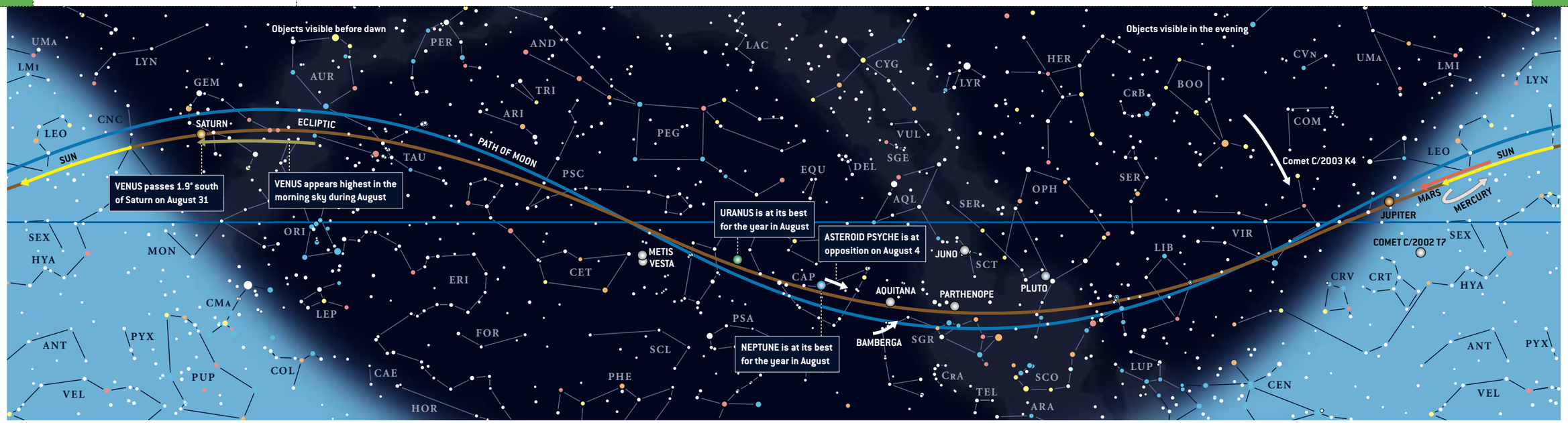
Planets this month

This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and colored dots show motions and locations of solar system objects during the month.



[17] [16] [15] [14] [13] [12] [11] [10] [09] [08] [07] [06] [05] [04] [03] [02] [01]

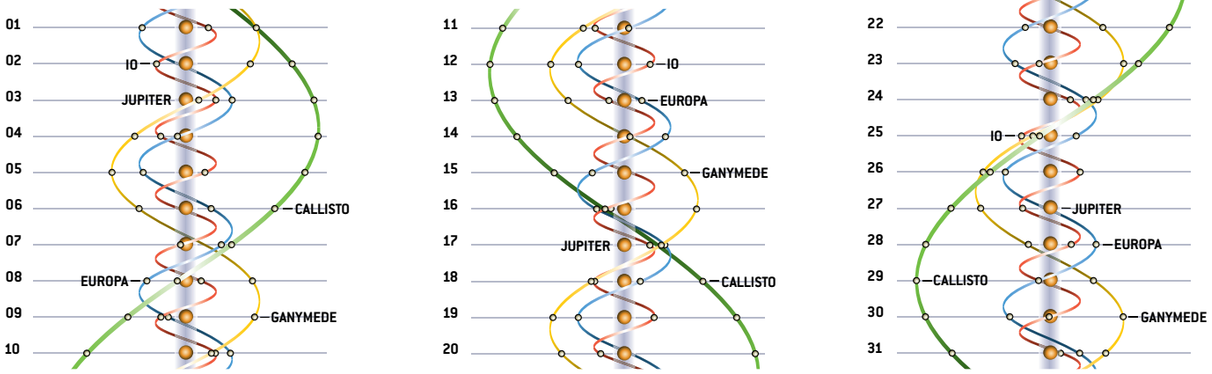
To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved blue line.

[31] [30] [29] [28] [27] [26] [25] [24] [23] [22] [21] [20] [19] [18] [17] [16] [15]

PLANETS	MERCURY	MERCURY	VENUS	VENUS	MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
Date	August 1	August 15	August 1	August 31	August 1	August 15	August 15	August 15	August 15	August 15
Magnitude	0.7	2.3	−4.4	−4.2	1.8	−1.7	0.2	5.7	7.8	13.9
Angular Size	8.4"	10.6"	28.9"	20.6"	3.6"	31.3"	16.8"	3.7"	2.3"	0.1"
Illumination	38%	11%	40%	57%	99%	100%	100%	100%	100%	100%
Distance (AU) from Earth	0.796	0.636	0.577	0.810	2.625	6.308	9.899	19.062	29.068	30.364
Distance (AU) from Sun	0.467	0.437	0.728	0.724	1.666	5.442	9.046	20.051	30.069	30.833
Right Ascension (2000.0)	10h25.9m	10h30.3m	5h37.1m	7h36.2m	9h46.7m	11h29.5m	7h32.7m	22h29.5m	21h04.7m	17h17.3m
Declination (2000.0)	7°32'	4°29'	19°04'	19°23'	14°36'	4°29'	21°31'	−10°20'	−16°47'	−14°24'

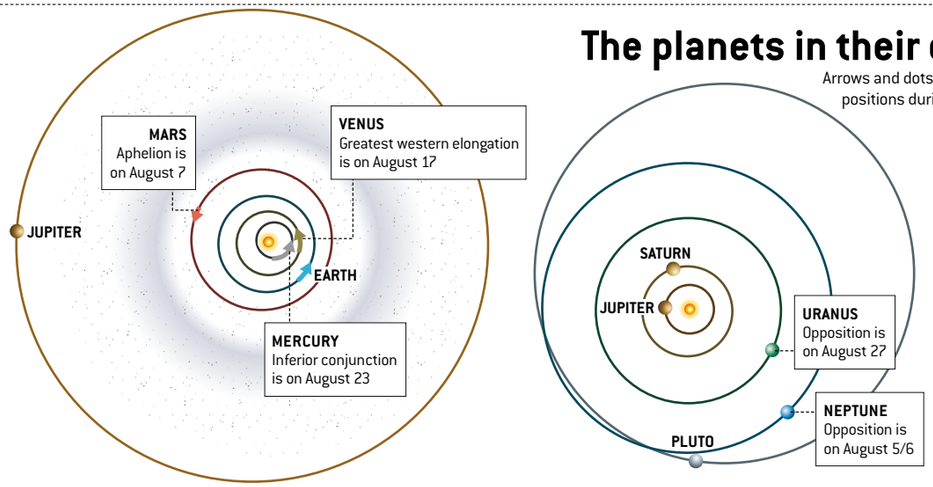
Jupiter's moons

Dots display positions of Galilean satellites at 11 P.M. EDT on date shown. South is at top to match the view in a telescope.



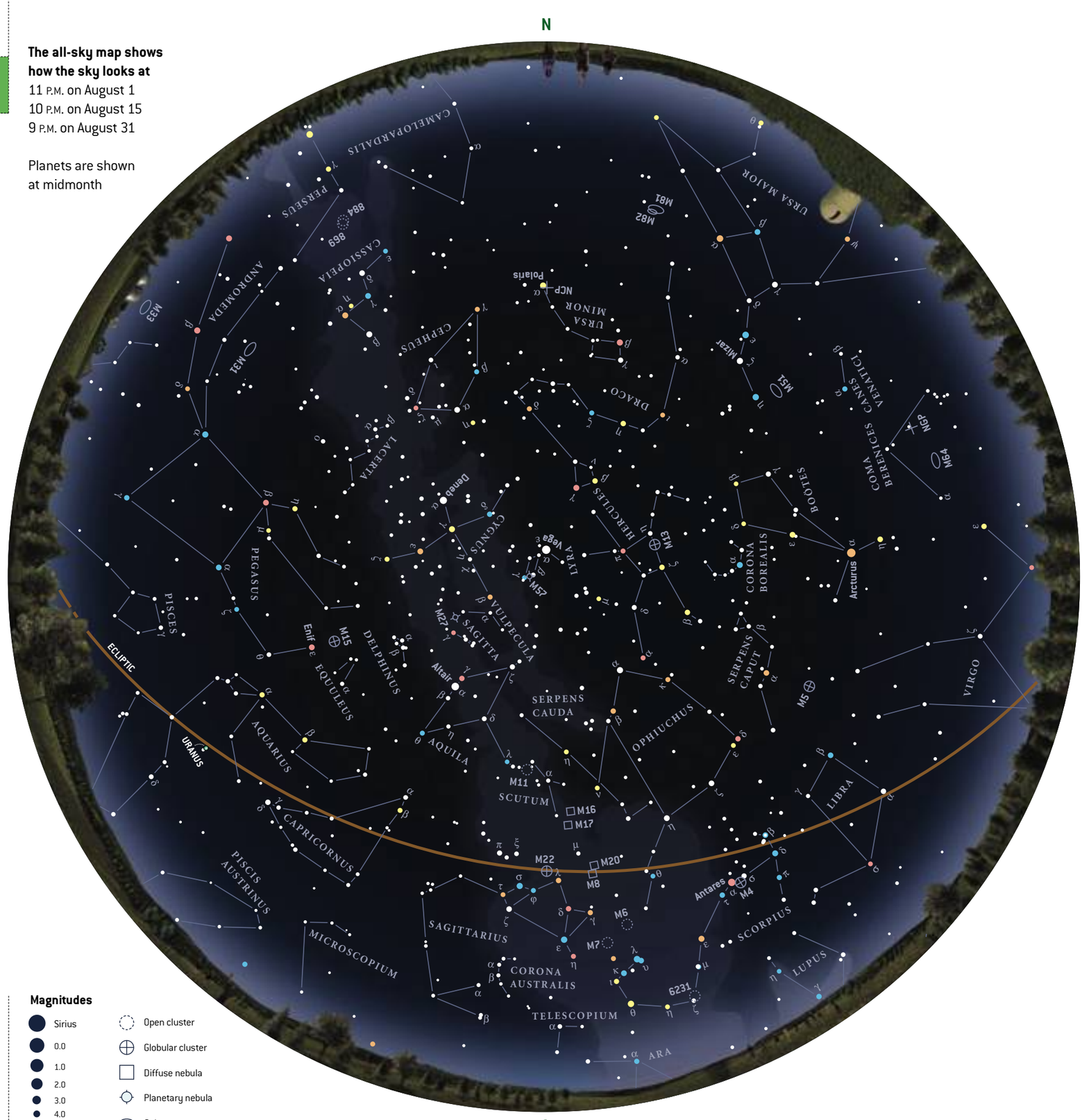
The planets in their orbits

Arrows and dots show planets' positions during the month.



The all-sky map shows how the sky looks at
11 P.M. on August 1
10 P.M. on August 15
9 P.M. on August 31

Planets are shown at midmonth



Magnitudes

- Sirius
- 0.0
- 1.0
- 2.0
- 3.0
- 4.0
- 5.0

- Open cluster
- Globular cluster
- Diffuse nebula
- Planetary nebula
- Galaxy

This map portrays the sky as seen near 35° north latitude at times shown in the upper left corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

august 04

SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
[01]	[02]	[03]	[04]	[05]	[06]	[07]
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[29]	[30]	[31]				

02 The Moon passes 4° south of Uranus, 8 A.M. EDT

04 Asteroid Psyche is at opposition, 6 A.M. EDT

05 Neptune is at opposition, 11 P.M. EDT

07 Last Quarter Moon is at 6:01 P.M. EDT

Mars is at aphelion (154.9 million miles from the Sun), 7 P.M. EDT

11 The Moon is at apogee (251,837 miles from Earth), 5:33 A.M. EDT

The Moon passes 8° north of Venus, 7 P.M. EDT

12 Perseid meteor shower peaks

13 The Moon passes 5° north of Saturn, 5 A.M. EDT

15 New Moon is at 9:24 P.M. EDT

16 Mercury passes 6° south of Mars, 11 P.M. EDT

17 Venus is at greatest western elongation (46°), 3 P.M. EDT

18 The Moon passes 3° north of Jupiter, 1 A.M. EDT

23 First Quarter Moon is at 6:12 A.M. EDT

Mercury is in inferior conjunction, 5 P.M. EDT

27 The Moon is at perigee (226,866 miles from Earth), 1:38 A.M. EDT

Uranus is at opposition, 3 P.M. EDT

28 The Moon passes 5° south of Neptune, 5 A.M. EDT

29 The Moon passes 4° south of Uranus, 4 P.M. EDT

Full Moon is at 10:22 P.M. EDT

31 Venus passes 1.9° south of Saturn, 9 P.M. EDT

For a definition of terms, visit www.astronomy.com/glossary

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Our Advanced Series and Advanced Series **Computerized GoTo** telescopes offer a selection of models with the **features, quality** and **value** even serious amateurs will appreciate like **heavy-duty German Equatorial mounts** with **ultra-sturdy 2" stainless steel legs,** center brace and accessory tray for superior stability, rigidity and vibration dampening. Choose from refractor, reflector, and Schmidt-Cassegrain models. Refractor models range from a 4" to an impressive 6" aperture. For more light gathering power there are 6", 8" Newtonian reflectors. **The NEW C6 N-HD comes with a CG-5 Heavy Duty German Equatorial mount and the NEW C6 N-GT features Dual-Axis slew motors, computerized hand control, and car battery adapter.** There are also 5", 8" and 9 1/4" Schmidt-Cassegrain optical designs that feature Celestron's **precision matched and hand-figured optical systems.**

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WHAT'S IN A NAME?

Here's a quick guide to identifying the various types of Celestron Advanced Series telescopes:

S = Schmidt-Cassegrain
N = Newtonian
R = Refractor
GT = Computerized GoTo
HD = Heavy Duty CG-4 Mount

Example: C10-NGT
10" Newtonian on a computerized mount.

CG-5 Mount — Precision engineered for stability.

Our **CG-5 German Equatorial Mount** has precision worm gears on both axes for extremely smooth tracking and slewing and uses a large shaft and bearings and substantial base castings for additional stability. A **new heavy-duty tripod** with **larger and more substantial legs** provides excellent damping characteristics for more stable views. There is a convenient **latitude scale** for easier alignment and an **optional polar finder scope** for the ultimate in precision alignments. The **C4 R** and **C6 N** both come with our rugged CG-4 mount.

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Optional CN16 GPS Accessory Kit (#93966).

C9 1/4-SGT (#11046)

Advanced GoTo models can also be upgraded to GPS with the optional **CN16 GPS Accessory Kit (#93966).** It contains the CN16 GPS module, bracket and holder, and Auxiliary Port Module.

C10-NGT (#11048)

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Remote Control Software

Celestron's new optional NexRemote remote control software allows alignment and operation of Advanced Series GT telescopes from a PC or laptop. For more information about Celestron's new NexRemote software, visit **www.celestron.com**.

CELESTRON TWO-YEAR WARRANTY

Celestron is so confident in the quality and performance of its telescopes, we stand behind them with a FULL TWO-YEAR WARRANTY. Compare this with other manufacturer's warranties or costly extended warranties.

C10-NGT (#11048): $1,199 + $95 S&H; C10-N (#11047):$909 + $75 S&H; C9 1/4-SGT (#11046): $1,779 + $105 S&H; C9 1/4-S (#11045): $1,469 + $85 S&H; C8-SGT (#11026): $1,359 + $75 S&H; C8-S (#11025): $1059 + $85 S&H; C8-NGT (#31062): $1019 + $85 S&H; C8-N (#31061): $699 + $65 S&H; C6-RGT (#21020): $1069 + $95 S&H; C6-R (#21019): $849 + $75 S&H; C6-N (#31056) $399 +$50 S&H; C6-N HD (#31053): $529 + $50 S&H; C6-NGT (#31054): $799 + $70 S&H; C5-SGT (#11072): $1,099 + $75 S&H; C5-S (#11071): $849 + $65 S&H; C4-R (#21016): $399 + $40 S&H

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- 2-step anodize process to prevent reflection from top surfaces
- Blackened lens edges

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#93318 - 9mm $44.00
#93319 - 12.5mm $44.00
#93320 - 15mm $44.00
#93321 - 20mm $44.00
#93322 - 25mm $44.00
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NEW!

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- 17 amp hour, 12 Volt D.C.
- 2 x 12V DC output car jack socket
- DC 3, 6, 9V output jacks
- Built-in AM/FM Radio and Siren
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- Built-in circuit breaker for safety
- Cigarette lighter adapter included
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X-Cel® Eyepieces — 1¼"

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- Fully Multi-coated. All air-to-glass surfaces have 5 layer multi-coating
- Field of view 55°
- Parfocal – little to no focusing adjustments are needed when switching from a low power to high power eyepiece
- 20mm eye relief and soft rubber roll down eyecups
- More than 25mm of clear aperture even on the high powers for comfortable high power viewing
- Each eyepiece comes with a durable plastic case

#93386 - 2.3mm $69.00
#93387 - 5mm $69.00
#93388 - 8mm $69.00
#93389 - 10mm $69.00
#93390 - 12.5mm $69.00
#93391 - 18mm $69.00
#93392 - 21mm $69.00
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Axiom® Eyepieces — 1¼", 2"

- **7-element optical design**
- **70° EXTRA WIDE** field of view (except 50mm)
- Fully multi-coated

1-1/4"

#93357 - 15mm $139.00
#93358 - 19mm $149.00
#93359 - 23mm $179.00

2"

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#93363 - 34mm $239.00
#93364 - 40mm $289.00
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10mm Plössl Reticle Eyepiece —1¼"

- Five-element guiding eyepiece
- Reticle pattern is a .0075" double spaced line system
- Multi-coated optics for increased contrast
- Long eye relief
- High power is ideal for guiding
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- Optional illuminator is required ($39)

#94169 10mm Plössl Reticle Eyepiece —1-1/4" $124.00

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- 12-volt rechargeable power supply
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- Five Superior Grade Plössl Eyepieces — 1.25"; Barlow Lens — 2x 1.25"
- Six Colored Eyepiece (Planetary) Filters; Moon Filter — 1.25"
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- **Three-element apochromatic design**
- 27mm clear aperture
- Fully multi-coated

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Microguide Eyepiece —1¼"

- Laser-etched reticle with built-in, battery illuminator
- Multi-coated 12.5mm Abbe (4-element) Orthoscopic
- Direct guiding on stars outside the center of the field of view
- Greatly improved off-axis guiding to capture much fainter, sharply focused guide stars without reducing limiting magnitude
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Erect Image Diagonal —1¼"-90°

•Amici prism design allows you to view sky objects at a comfortable 90° and view land objects oriented properly, meaning the image is upright and correct from left to right.

#94108 - Erect Image Diagonal —1-1/4"-90° $39.00

Erect Image Diagonal —NX4

•Amici prism design allows you to look into your NexStar 4 at a 45° angle, and view land objects oriented properly, meaning the image is upright and correct from left to right.

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- Use with Schmidt-Cassegrain telescopes in prime focus, deep-sky imaging or astrophotography
- Simultaneously photograph and guide through the optical tube assembly of the telescope
- Adjustable prism and rotating eyepiece collar give wider section of sky for finding a guide star
- Eliminates the problem of differential flexure

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Reducer/Corrector

- Works with all Celestron C5, C8, C9-1/4 , C11 and C14 telescopes
- Minimizes coma and flattens field of view for pinpoint off-axis stars
- Reduces exposure times by 60% and increases field of view
- f/6.3 for C5, C8, C91/4 and C11 telescopes and f/7 for the C14 telescope

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2" Mirror Diagonal

- 2" 90° Mirror Diagonal to thread on Schmidt-Cassegrain telescopes
- Includes an adapter to use with refractor telescopes
- Includes an adapter to accept 1-1/4" eyepieces
- Multi-coated mirror
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NEW!

- Perfect for chilly evenings outdoors, camping, stargazing, or at sporting events
- Convenient, reusable, and made from nontoxic materials
- Heat lasts up to 1 hour

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NEW!

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- Use the power and accuracy of GPS satellites to align your telescope with the optional CN-16 GPS Accessory. Plug the GPS receiver module into your telescope to link up and automatically download information from one of many global positioning satellites
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Vibration Suppression Pads

- Reduces vibration time by almost 100% and decreases vibration amplitude
- The pads fit between the bottom of the tripod legs and the ground

#93503 - Vibration Suppression Pads (3) $59.00

Contrast - Booster Filter —1¼"

by Baader

- Eliminates color aberration inherent inachromatic refractor telescopes
- Eliminates the blue hue around lunar and planetary subjects
- Multi-layer coatings for 95% transmission

#94121 - 1-1/4" Contrast-Booster Filter $49.00

Model A — for 1-1/4" eyepieces

Model B — for back threads of SC's

LPR (Light Pollution Reduction) Filters

- Made of high quality, flat polished optical glass
- Over 40 layers of coating
- Broadband anti-reflection coating prevents ghosting and improves contrast

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- Transmits only light moving along a specific plane; increases contrast between surfaces with different planar transmissions
- Polarization effect makes blue skies a deeper blue, eliminates surface reflections and helps reduce atmospheric haze

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Eyepiece Filter Sets —1¼"

- An invaluable aid in planetary and lunar observing
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- Lessens eye fatigue

#94119-10 (21, 80A, 15, Polarizing) $44.00
#94119-20 (12, 25, 56, ND-25) $44.00
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- Adjustable brightness
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THE DEEP SKY

As if protected by the great stinger, glittering star clusters and glowing gas clouds float majestically on the back of Scorpius the Scorpion.

There's nothing quite like lying back and staring up at the center of the Milky Way Galaxy arching overhead. For dedicated deep-sky observers, it's nearly as impressive as a total solar eclipse. Unfortunately, you need to travel south of the equator to make this dream come true. Yet even from mid-northern latitudes, the sight of Sagittarius the Archer and Scorpius the Scorpion dazzles.

The bright stars of the scorpion's tail twinkle near the horizon. If you scan this region with binoculars, a bright triangular grouping of stars quickly stops your sweep. This visual gem includes Zeta^1 (ζ^1) and Zeta^2 (ζ^2) Scorpii. The brighter component (Zeta^2) appears distinctly yellow, while Zeta^1's white hue typically is tinged with some atmospheric color.

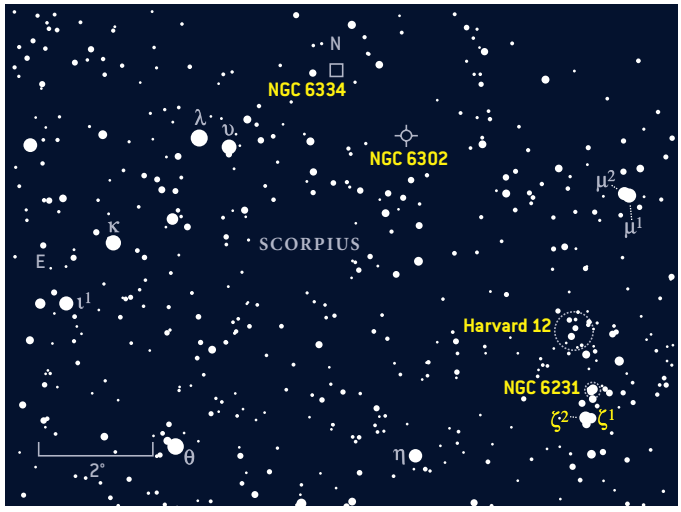
Immediately above this pair you'll see a bright knot, which a telescope turns into a magnificent, compact star cluster that ranks among most observers' top-ten clusters. Truly a sight to savor, NGC 6231 boasts ten stars brighter than magnitude 7.0 and appears more densely packed than the core of the Beehive cluster. Discovered by French observer Nicolas Louis de Lacaille around 1750, NGC 6231 is one cluster that you can keep pouring on the magnification. The higher the power, the more tight doubles and triples you'll see.

Then go back to a lower power and sweep slightly north to land on the sprawling splash of stars cataloged as Harvard 12. At first it may surprise you that both William and John Herschel missed H12 in their systematic searches of the sky. Their 18-inch telescopes had one characteristic very different from modern scopes — a small field of view, only 15' across, equivalent these days to about 250x with a wide-angle eyepiece. This part of the Milky Way is packed so densely with stars that the Herschels literally swept right across H12 without being able to see it in a wide-field context.

The nebulous glow of IC 4628 surrounding H12 stands out when seen through an OIII filter. This gas cloud proves a real challenge for northerners compared with the easy find in 8x50 binoculars from south of the equator. Slide north again at low power and you'll run into NGC 6242, a lovely star cluster having the shape of the small Greek letter lambda (λ).

On any color image of the Scorpion's tail, a conspicuous red "star" appears to the right of the stinger stars. Even a small telescope will reveal something quite odd: a squashed blob nicknamed the Bug Nebula (NGC 6302). Like many other planetary nebulae, the Bug can take a lot of power, and that's the only way to see its details. A bright knot of gas nearly hides the central star. A darker lane just west of center breaks the Bug's elongated shape. An OIII filter will mask the central star and show fainter extensions rising out of the background.

Although the Lagoon and Trifid nebulae to the north in Sagittarius certainly appear more spectacular, if you like hunting for rarer treasures, spend some time on the Cat's Paw Nebula. Plotted as NGC 6334 on most atlases, this group of five nebulae is easier to see on photographs than visually. The farther south you live, the better the view. You'll need a high-contrast filter to pull the fainter wreaths of nebulosity through the glow of our atmospheric shield.



THE BUG NEBULA sports a distinctive reddish glow from its perch near the stinger of Scorpius. KEN AND MATT BLANKENSHIP

Martin Ratcliffe *is former president of the International Planetarium Society.* **Alister Ling** *is a meteorologist for Environment Canada.*

THE PLANETS

Two gas-giant planets reach opposition this month, the peak of their year-long apparitions, while the early morning sky offers a close conjunction between Venus and Saturn.

The sky before dawn hosts a couple bright planets this month: Venus ascends to the peak of its outstanding morning apparition, and Saturn returns to view after a brief sojourn behind the Sun. Meanwhile, two giant yet distant planets reach opposition in August — both Uranus and Neptune appear at their best around midnight.

The sky after sunset appears much more barren. Lonely **Jupiter** can be viewed for a brief period in the darkening twilight throughout August, although by the end of the month, it sets soon after the Sun. On the 1st, Jupiter sets nearly 2 hours after the Sun, a value that drops to 45 minutes by month's end. Through a telescope, the planet's low-contrast atmospheric features still show up during twilight and offer an attractive subject against a deep-blue sky. The four bright Galilean moons also prove to be easy targets.

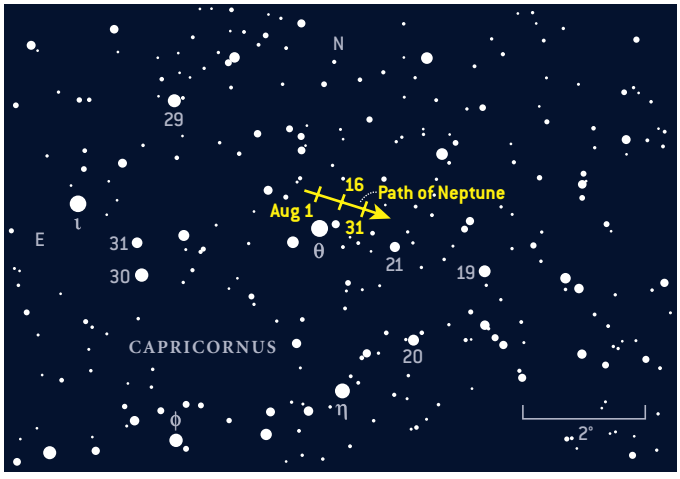
On the evening of August 17, look for Jupiter 4° to the left of the waxing crescent Moon about a half hour after sunset. Bright twilight will hinder the view, but you should be able to see them before they set an hour after the Sun.

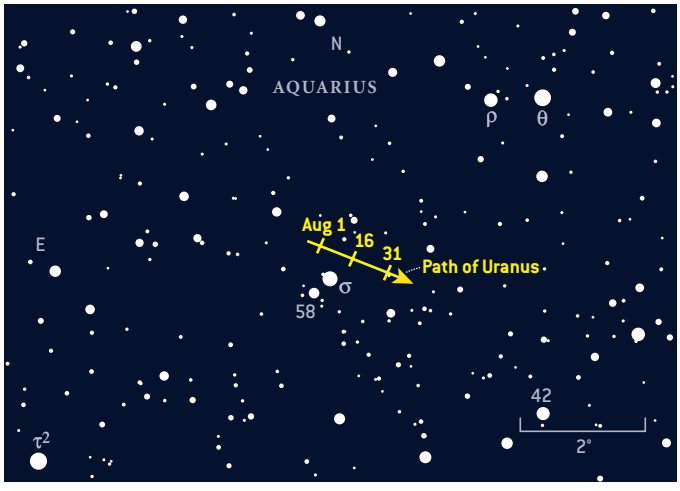
Mercury proves a tougher object to find, appearing even lower in the west after sunset in early August. You can spy the inner planet in the bright twilight about 13° to the lower right of Jupiter. Don't confuse Mercury with Regulus, Leo's brightest star, which lies 7° to its right. The planet shines at magnitude 0.7, noticeably brighter than the star. Mercury disappears from view by the end of the first week in August and passes between the Sun and Earth on the 23rd. It reappears in the morning sky in early September.

This past spring, all five planets known since antiquity were on view during the evening hours, spanning the sky from east to west. Uranus and Neptune glow much fainter and were unknown until their discoveries in 1781 and 1846, respectively. Both planets come to opposition this month and can be spotted through binoculars if you know where to look.

Neptune reaches opposition on August 5/6 near the 4.1-magnitude star Theta (θ) Capricorni. As August opens, the gas-giant planet conveniently lies one Moon-width above Theta. This makes the eighth planet an easy target. For the best views, wait until midnight approaches, when this region lies due south and is at its highest point above the horizon. Viewing over two or three consecutive nights easily reveals the planet's motion and confirms its identity.

Neptune also glows its brightest of the year, magnitude 7.8, at opposition. Several 9th-magnitude stars surround it, helping to aid in the planet's identification. During August, Neptune tracks westward against these background stars, ending the month northwest of Theta and forming a triangle with it and the 6th-magnitude star 21 Capricorni. Neptune's retrograde motion continues until late October. At opposition, the planet lies about 29 astronomical units away from Earth, or 2.70 billion miles. (One astronomical unit, or AU, equals the average distance between Earth and the Sun, or about 93 million miles.)





Farther to the east, you can find **Uranus** wandering among the stars of Aquarius. This position places Uranus at opposition on August 27. On the 1st of the month, Uranus lies one Moon-width north of the 4.8-magnitude star Sigma (σ) Aquarii. This region, centrally located in the faint constellation, contains few bright stars. On the same night, the Full Moon lies 6° south of the planet. Despite the Moon's

glare, Uranus should be visible through binoculars. The planet glows at magnitude 5.7, about one magnitude fainter than Sigma. Uranus tracks to about 1° west of Sigma by August 31. At opposition, Uranus lies 19 AU away from Earth, or 1.77 billion miles. It takes light more than 2.6 hours to cover this distance. Point a telescope at the planet and you should resolve its 3.7"-diameter disk, which appears distinctly blue-green in color.

Venus appears conspicuous in the east before dawn during the entire month. Shining at magnitude –4.3, it's brighter than any other point of light in the sky, and it reaches the peak elevation for its current apparition. In early August, Venus lies south of the southern tip of Taurus the Bull's horns. By 4 A.M. local daylight time, the planet has climbed well above the eastern horizon. Through a telescope, its disk spans 29", a value that shrinks to 21" by month's end. Over the same period, its phase waxes from 40 percent to 57 percent lit. It crosses the half-lit threshold on August 17, when it reaches its greatest elongation west of the Sun (46°).

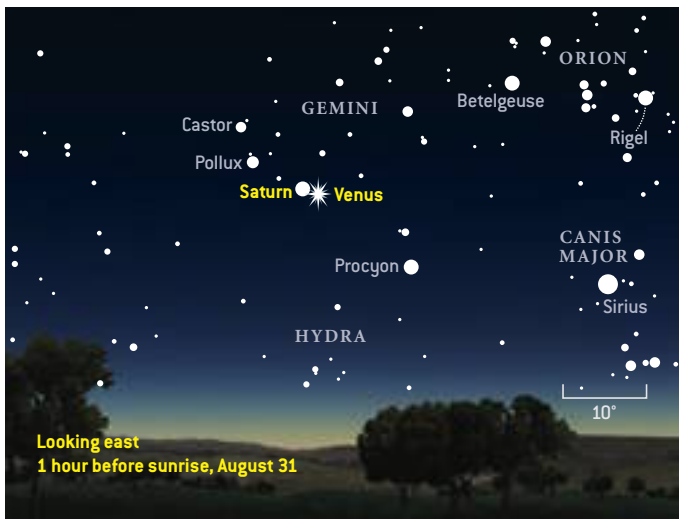
On August 1, **Saturn** rises in the east-northeast just as dawn breaks, 90 minutes before sunrise. Venus lies to Saturn's far upper right in Taurus. By mid-August, Saturn stands 10° above the horizon as dawn breaks. Venus has moved into Gemini the Twins by then, having crossed the northern reaches of Orion between August 4 and 12. (Venus's path takes it 5° south of the bright star cluster M35 on August 9.)

Venus keeps approaching Saturn during the second half of August in preparation for a superb conjunction at month's end. Amid the stunning backdrop of the winter constellations, Saturn and Venus stand just 2° apart on the 31st. The pair then rises nearly 4 hours before the Sun. Their close conjunction is a line-of-sight effect only. In reality, a giant chasm of more than 800 million miles separates the two planets.

Since Saturn disappeared in the Sun's glow in June, it has been joined by the Cassini spacecraft. Our view of Saturn and its retinue of moons will change forever as the Cassini mission continues to orbit the ringed planet for the next several years. In the quiet, early morning hours, grab your scope and take a look at magnificent Saturn. It currently shines at magnitude 0.2, and its disk measures 17" across. The rings span 38", more than double the planet's size.

Also look for Titan, Saturn's largest moon, which glows at magnitude 8.3. It's the target of the European probe Huygens, which is scheduled to parachute through the moon's thick atmosphere and land on its surface this coming January. Titan shows up easily in a small telescope. It lies due east of Saturn on August 4 and 20 and due west of the planet on August 12 and 28. Saturn's other moons prove more difficult to find because they glow significantly dimmer and lie closer to the bright planet. The easiest ones to glimpse are the three 10th-magnitude satellites: Tethys, Dione, and Rhea.

VENUS GLEAMS BRILLIANTLY beneath a slender crescent Moon in early evening twilight in this photo. During August, Venus dominates the morning sky. TIM BARNWELL



METEORS AND MOONS

With the Moon out of the way, the Perseid meteor shower should yield an impressive display this year. But if predictions hold true, the shower could be better than ever.

Summer's grand show

As meteor showers go, the Perseids rank among the most reliable. This year's shower promises to be one of the best thanks to a couple factors. First, the Moon barely interferes at all, and second, the potential exists for significantly increased rates on the nights of August 10/11 and 11/12.

Unlike last year, the Moon will be a minor nuisance at worst in 2004. A 19-percent-illuminated crescent rises around 2:30 A.M. local daylight time on August 11. By the next morning, the Moon has waned to just 12 percent lit and doesn't rise until 2:30 A.M. So the Moon has no effect for most of both nights and interferes only negligibly in the immediate predawn hours.

Some astronomers predict a sharp peak in activity this year at 21h UT on August 11; unfortunately, that's during daylight in North and South America. The prediction comes from a detailed study of debris ejected by Comet 109P/Swift-Tuttle, the parent comet of the Perseids. Meteors result when Earth runs into the debris left behind by comets as they orbit the Sun.

In the case of Swift-Tuttle, enhanced meteor rates were seen in the early 1990s, near the time it last reached perihelion, the closest approach to the Sun during its 130-year orbit. But streams deposited during previous returns to the Sun's vicinity also can enhance rates — if Earth runs into them. Debris trails tend to dissipate over time due to the combined gravitational influence of the Sun and planets. More recent trails tend to be narrow, producing sharp but brief peaks of activity.

This year, Earth should run into a narrow debris trail left behind by Swift-Tuttle during its 1862 return to the inner solar system. Esko Lyytinen, the Finnish researcher who made accurate predictions for the past several Leonid meteor showers, predicts an outburst of up to a few hundred meteors per hour at 20h54m UT on August 11. This peak might last only 15 minutes. The timing of this event favors observers in Europe and Asia. Those in North America may see enhanced rates on the mornings of August 11 and 12.

The traditional peak of the Perseid shower arrives at 11h UT (7 A.M. EDT) on August 12. Although this tends to favor observers in eastern Asia, the peak is broad and should offer good viewing opportunities for everyone in North America during the early morning hours of the 12th.

A PERSEID STREAKS toward the horizon in this view of the 1994 shower. Astronomers think we may be in for a spectacular show this year. DAN SMILEY

THE CRATER ERATOSTHENES, with its terraces and central peak, lies near the western end of the lunar Apennines. FROM *THE CONSOLIDATED LUNAR ATLAS* (LPL/UA)

End of the Apennines

The well-known crater Eratosthenes lies at the southwestern end of the lunar Apennine Mountains, not far northeast of Copernicus. Eratosthenes appears dramatic as the Sun rises over it when the Moon is nine days old. The crater measures 36 miles across and exhibits a nice central peak and mountainous ridges across its floor. The most impressive mountain ridge runs north to south inside the deep crater.

The terrain surrounding Eratosthenes is quite chaotic. The rugged Apennines connect to the crater's northern wall, while patterns of hills and minor craters dot the surrounding ramparts. The day after the Sun rises over Eratosthenes, the terraced inner walls become illuminated. By Full Moon, the crater appears washed out, as do most lunar craters under full illumination. This month, you can watch the Sun rise over Eratosthenes on August 24, and then, follow its changing appearance each successive night.

COMETS AND ASTEROIDS

As two nice comets cruise the early evening sky, a pair of bright asteroids that lie next to each other comes into viewing range after midnight.

Backyard comets

Snowball season remains in effect for one of the warmest, and most popular, observing months of the year. Naturally, the best place for you to view a comet is from a site far away from the city's veil of light pollution — particularly if you want to see the full extent of the comet's tail. But if you can't make it, both comets C/2001 Q4 (NEAT) and C/2003 K4 (LINEAR) should stay within small-scope range from a suburban backyard.

C/2001 Q4 patrols the sky fairly low in the north, above the bowl of the Big Dipper asterism in Ursa Major. At about 7th magnitude, the comet glows about as bright as the M81/M82 pair of galaxies off to the side. On Friday evening, August 20, with the Moon out of the way, Q4 floats between two 11th-magnitude galaxies, NGC 4036 and NGC 4041. A 6-inch scope will have little trouble showing the trio.

Don't be afraid to push the magnification up a bit. The field becomes darker, but once you adapt and throw a hood over your head to cut out background light, you'll be able to see more. Take the time to study the different shapes and brightness profiles of the three objects; the comet should have a much more noticeable core, and the galaxies will appear quite elongated.

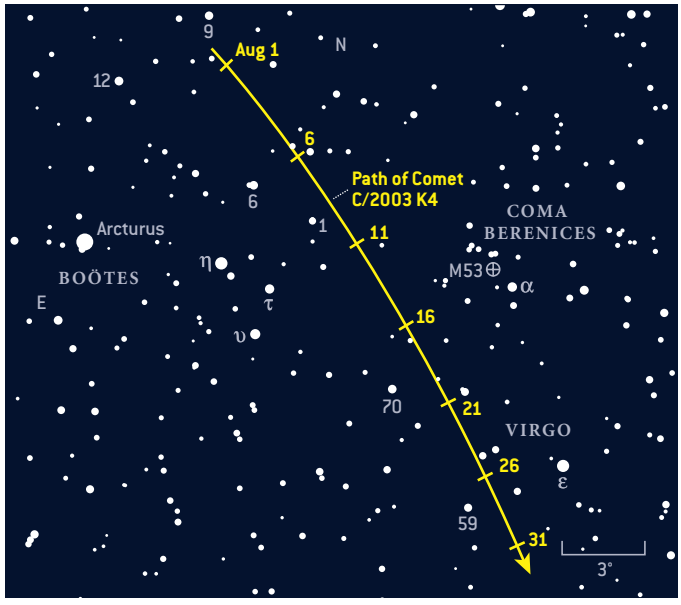
Sixth-magnitude C/2003 K4 sets before midnight, so set your sights on it first. This month, it tracks from Boötes through Coma Berenices and into Virgo, a corner of the sky that also contains globular cluster M53. The comet and cluster should look pretty similar, but this is only an illusion. K4 lies millions of miles away in our solar system, while M53 shines across 60,000 light-years. This great distance reduces the cluster's brightest stars to an apparent magnitude of a mere 13.8. With an 8-inch scope on a dark, steady night, you'll be able to see these bright stars causing granulation against the glow of the fainter swarm.

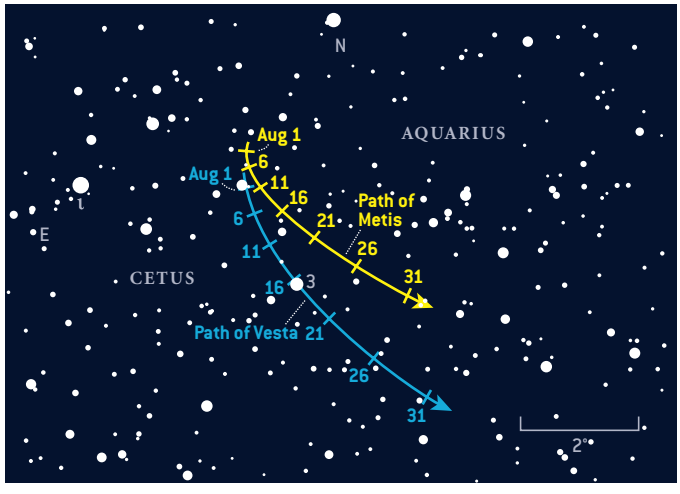
Another nice conjunction occurs on August 22 and 23, when 11th-magnitude Comet C/2003 T3 (Tabur) slides just south of the 9th-magnitude galaxy NGC 2841 in Ursa Major. The observing challenge here is that the pair lies just 10° or so above the northern horizon as darkness falls.

Vesta and Metis part

With no bright asteroids to check out during the early evening, we need to wait until midnight for a peek at Vesta and Metis. These space rocks lie together south of the Pisces Circlet, near Iota (ι) Ceti, just below the waning gibbous Moon on August 3. You'll have to wait a few days to let the bright Moon move out of the way before you can see the asteroids well.

Vesta, the fourth of the "Big Four" asteroids discovered in the first decade of the 19th century, will be easy to spot. At magnitude 6.5, it ranks among the brightest objects within a 2° circle (about twice the field of a low-power eyepiece). On the night of August 16, watch Vesta separate from a very close encounter with the 5th-magnitude star 3 Ceti.





Metis proves trickier to find because it glows three magnitudes fainter than Vesta. Only 1 percent farther away than Vesta, Metis appears much dimmer because it has a darker surface and a diameter of just 105 miles, one-third of Vesta's size, so it reflects a lot less sunlight in our direction.

Anyone can sell you a telescope.

Selling you the right telescope means listening carefully to what *you* want to see and do with a telescope – to match your needs and dreams to your budget. It means answering your questions truthfully and fully. It means taking the time to explain your options. It means using our experience – a staff total of over 160 years of experience using and selling telescopes – to make sure that you get the scope and accessories that work together properly and do what you want to do . . . the scope and accessories that are right for *you.*

We've been helping people choose the right telescope since 1979. We have the experience to help *you* pick the scope that fits your needs (and your budget) from the hundreds of telescopes we stock. And, with our seven-figure inventory, we can usually ship you the right scope right away.

We started ***astronomics*** over 25 years ago because we loved astronomy, not just as a business. Our sales may have grown over a thousand-fold since that first year, but we're still the same family-owned, family-run, full-line telescope dealer we were in 1979. And we still love astronomy.

astronomics. No hard sell. No guesswork. Just honest advice, the time to make sure you get the right telescope and accessories, and a good price. Call us toll free at (800) 422-7876 and find out for yourself.

More than 1,000,000 people a year visit
www.astronomics.com
for reliable information, helpful features, and secure on-line shopping.

> The quality of the telescope and the accessories that I purchased from you are first rate. More importantly, the quality of service and the willingness to accomodate me, the customer, was outstanding! In today's marketplace this is a lost art. Keep up the outstanding work.
>
> **Customer Quote of the Month #149**

We ship Meade LX200GPS-*SMT* go-to scopes from stock.

Meade 8" LX200 GPS SMT
$2195

Meade prices are about the same anywhere you call. So why order a 7" through 10" Meade telescope from a dealer who charges your credit card, then makes you wait and wait until he finally gets around to ordering what you want? Not when you can usually get the Meade you want . . . right now . . . at the right price . . . right here at ***astronomics.***

Meade LX200GPS-SMT telescopes have all the performance and features you've dreamed about since you started astronomy – plus you can add optional UHTC (Ultra High Transmission Coatings) for 20% more light transmission so you can see 20% more of the Universe.

Fully automatic GPS (Global Positioning System) alignment takes the time and guesswork out of setting up your LX200 and aligning it on the sky. You start observing in minutes.

New and unique Smart Mount Technology can improve your scope's pointing accuracy as you observe. A supplied Lunar Planetary Imager takes digital color pictures for you.

The GPS Autostar computer has a built-in database of over 145,000 stars and objects. It finds any of them for you *automatically.* You'll spend more of your time looking *at* heavenly bodies and less time looking *for* them.

Optional Meade Sky Assurance™ extended service programs can extend your telescope warranty to three or five years – *or longer!*

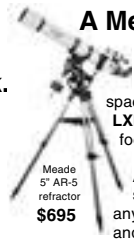
Here are the LX200GPS scopes we ship from our stock:

7" Maksutov-Cassegrain ..... **$2695**^{00}
7" Maksutov-Cassegrain, w/UHTC ..... **2845**^{00}
8" Schmidt-Cassegrain ..... **2195**^{00}
8" Schmidt-Cassegrain, w/UHTC ..... **2370**^{00}
10" Schmidt-Cassegrain ..... **2745**^{00}
10" Schmidt-Cassegrain, w/UHTC ..... **2980**^{00}

Here are the LX200GPS scopes Meade ships from the factory due to their weight:

12" Schmidt-Cassegrain ..... **3595**^{00}
12" Schmidt-Cassegrain, w/UHTC ..... **3890**^{00}
14" Schmidt-Cassegrain ..... **4695**^{00}
14" Schmidt-Cassegrain, w/UHTC ..... **5045**^{00}
16" SCT, w/altazimuth pier and UHTC .... **15,645**^{00}
16" SCT, w/equatorial pier and UHTC ..... **15,845**^{00}

A Meade LXD55 makes astronomy easy.


Meade 5" AR-5 refractor
$695

Even if you don't know the skies at all, you won't spend all of your time hunting for planets and deep space wonders with a 5" or 6" **Meade LXD55** achromatic refractor or a fast focal ratio 6", 8", or 10" reflector.

A few touches on the scope's Autostar computer hand control sends your LXD55 speeding to any of the more than 30,000 stars and objects in its memory and tracks it accurately for as long as you want to observe.

You simply spend more of your time looking *at* celestial objects and less time looking *for* them with a go-to computerized Meade LXD55.

Each is complete with an adjustable height tripod, dual motor drives, an accessory tray, finderscope, eyepiece, and Autostar computer that takes the guesswork out of finding your way around the skies.

Meade 8" SN-8 f/4 reflector
$839

We actually stock TeleVue. Does your dealer?

NP-101 **$3595**

To sell seven figures worth of TeleVue a year, you have to keep a lot of it in stock so you can ship fast and keep your customers happy. We *do* keep a big inventory on hand, so our customers are *very* happy. Others may say they carry TeleVue, *but we actually keep TeleVue in stock.* Lots of it.

Here are a few of the TeleVue refractors that we keep in stock for immediate shipment.

TV-76, 3" f/6.3 apo ..... **$1675**^{00}
TV-85, 3.35" f/7 apo ..... **2080**^{00}
TV-102, 4" f/8.6 apo ..... **2635**^{00}
Renaissance 102, 4" f/8.6 brass apo ... **3175**^{00}
NP-101, 4" f/5.4 apo ..... **3595**^{00}

All of the above refractors come without a mount, but include a TeleVue Plössl eyepiece (except the NP-101), an enhanced aluminum or 99% reflectivity Everbrite star diagonal, a carrying case, and a tube ring for mounting.

Optical tubes only, without these accessories (such as the new **TV-60** apochromatic at $795), are also available from stock.

Speaking of TeleVue accessories, we stock them all. For example, here are a few of the latest TeleVue eyepieces that we can ship to you today.

2-4mm 1.25" Nagler zoom ..... **$395**^{00}
2.5mm 1.25" Nagler Type 6 ..... **280**^{00}
3.5mm 1.25" Nagler Type 6 ..... **280**^{00}
11mm 1.25" Nagler Type 6 ..... **280**^{00}
20mm 2" Nagler Type 5 ..... **440**^{00}
41mm 2" Panoptic ..... **495**^{00}

Whether it's a Gibraltar, Panoramic, or Tele-Pod mount; a Sky Tour computer; a Nagler, Radian, Panoptic, or Plössl eyepiece; Barlow or Powermate; Everbrite 99% reflectivity star diagonal; light pollution filter, or a BinoVue – if it's TeleVue, it's in stock.

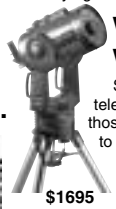
Everyone can afford CCD when cameras start at $249!

SAC7B cooled 24-bit color
$499

Low cost **SAC Imaging** CCD cameras finally make serious CCD imaging possible at sensible prices. Even the owners of small telescopes such as the Meade ETX-90 can do serious CCD imaging with a very affordable SAC camera.

Whether it's short exposure lunar and planetary shots, long exposure deep space photos, black and white imaging, single-pass full color, tri-color with a filter wheel, or auto-guiding – there's an inexpensive SAC CCD camera to do it. You'll find full details and pricing on all of them on our website at **www.astronomics.com**.

Why wait for another dealer to *order* your scope? We'll ship your Meade LX90 from our stock now.


$1695

Some dealers don't even stock the telescopes they sell. Why wait for one of those non-stocking dealers to get around to ordering an LX90 for you to enjoy?

We typically keep a dozen or so Meade LX90s in stock at all times. You can usually get *your* LX90 from us with little or no delay.

The **Meade LX90** 8" go-to costs only $1695. It has a heavy-duty adjustable height tripod, Super Plössl eyepiece, Autostar computer with 30,223 star and object memory, and an 8 x 50mm finder. Order your LX90 from us today. You'll probably be observing with it within a week.

Compact enough to travel, big enough for serious seeing.

5" ETX-125EC
$995

Best-selling **Meade ETX** Maksutov-Cassegrains are compact enough to take with you and use anywhere – from a light-polluted city or suburb to a distant dark sky site. And their superb optics will keep you happily observing for years. Prices start at $595 for a 3.5" ETX-90 go-to scope with everything you need to start observing as soon as you get it. Each has an adjustable height tripod; an Autostar computer with a memory of 30,223 stars, deep space objects, and planets it can find and track for you; finderscope; 26mm Super Plössl eyepiece; and more.

A compact and easy-to-use Meade ETX Maksutov makes astronomy easy – and we have them all in stock now!

Big binoculars. Bright images. Little prices.

$89

**$99**^{95}

$349

You don't need a telescope to enjoy astronomy. Many of the wonders of deep space – nebulas, galaxies, and star clusters – are all visible through Celestron binoculars, as are myriad craters and mountains on the Moon.

The **10 x 50mm LPR Optiview**, left, is a good conventional binocular that also has a secret weapon for astronomy. Built-in light pollution filters block the glare of city lights that can wash out faint deep space nebula detail.

The **15 x 70mm Skymaster**, left, shows you detailed views of the night sky for *very* little cash.

The big **25 x 100mm Skymaster** shown above (which has the light-gathering power of two 4" telescopes, one for each eye), and the similar but physically smaller **20 x 80mm Skymaster** at $279, not shown, gather huge amounts of light for serious deep space observing. All Celestron Skymaster binoculars include an adapter for use on a photo tripod.

A feature-packed 6" Celestron Dob is only $249.

8" f/6 StarHopper
$369

The new **Celestron StarHopper Dobs** are loaded with useful features. Instead of Teflon or plastic pads sliding on Formica to support the scopes, roller bearings with dozens of support points ride on a broad azimuth track for smooth hitch-free horizontal motion. Altitude bearings ride on nylon rollers for an equally smooth vertical motion. There's a variable tension altitude clutch to compensate for different eyepiece weights. The finderscopes (6x30mm on the 6"; 9x50mm on the 8" through 12") are mounted in easy-to-align quick release brackets. The 8" through 12" scopes use a 2" metal rack and pinion focuser (with 1.25" adapter) and come with a 2" 32mm E-Lux eyepiece (the 6" scope has a 1.25" metal rack and pinion focuser and 25mm Plössl). The 10" and 12" scopes have a built-in battery-operated cooling fan for their primary mirrors. All have fast cool-down metal tubes and BK7 optical glass mirrors.

Here are the prices for the fully-equipped Celestron StarHopper Dobsonians.

6" f/8 StarHopper ..... **$249**^{00} + $49 freight
8" f/6 StarHopper ..... **349**^{00} + $59 freight
10" f/5 StarHopper ..... **499**^{00} + $69 freight
12" f/5 StarHopper ..... **849**^{00} + $99 freight

Big right-angle finders at small prices.

Antares 12 x 80mm
**$174**^{95}

We stock **Antares** 8 x 50mm and 12 x 80mm right angle finders priced sensibly from $79^{95} to $239^{95}. Choose from a Celestron black, Meade blue, or gloss white finish in standard mirror-image versions as well as erect right-reading models that show you the sky the way it appears on star charts. Each is available with either dark crosshairs or a unique built-in cordless red disk illuminator. Economical optional quick release mounting brackets are also available.

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680 SW 24th Avenue, Norman, OK 73069

Toll-Free Order Line: **(800) 422-7876** Catalogs/Questions/Advice: **(405) 364-0858**

We'll sell you the *right* telescope.

This month's products of note . . .
Barlows to double your available eyepiece powers.

A modern Barlow can often improve eyepiece performance *and* effectively double your eyepiece collection for little extra cost. Here's a *partial* list of the name-brand Barlows we stock:

Celestron 2x 1.25" w/T-adapter **$44.95**
2x 1.25" Omni **39.95**
2x 1.25" Ultima 3-element apo **79.95**
Meade #124 2x 1.25" for ETX70 ..... **39.95**
#126 2x 1.25" for ETX90/105/125 ..... **47.95**
#128 3x 1.25" for ETX70 ..... **39.95**
#140 2x 1.25" 3-element apo **79.95**
TeleVue 2x 1.25" **$105.00**
2x 1.25" **105.00**
2.5x 1.25" 4-element Powermate **190.00**
5x 1.25" 4-element Powermate **190.00**
2x 2" Big Barlow **198.00**
2x 2" 4-element Powermate **280.00**
4x 2" 4-element Powermate **295.00**
TMB 1.8x 1.25" ED **250.00**
Vernonscope 2.4x 1.25" Dakin **169.50**
Vixen 2x 1.25" **45.00**
2x 1.25" DX 3-element **100.00**
3x 1.25" **60.00**

Only $995 for a 5" GPS-ready Celestron SCT.

The **Celestron NexStar 5i** is the *only* 5" telescope to have a fully automatic GPS go-to computer available as an option. No other 5" scope has GPS available! The NexStar 5i has a computer hand control with a 45,000+ star and object database, adjustable height tripod, red dot finder, eyepiece – everything you need to start observing immediately!

Multicoated optics are *standard equipment* with the Celestron NexStar 5i, not an option as with other scopes. NASA uses Celestron 5" multicoated optics on the Space Shuttle. Don't your eyes deserve the same premium image quality? **$995**

the Nexstar 5i is shown with optional photography accessories

Our *38* light pollution filters make bright skies dark.

Are city lights washing out your view of the skies? Improve your deep space observing by dimming those annoying lights with one of the many light pollution reduction filters we stock.

We have two **Celestron** broadband filters. One is designed for 1.25" eyepieces; the other for Schmidt-Cassegrain (SCT) rear cells.

We have 13 **Lumicon** Deep Sky broadband, UHC narrowband, and H-Beta and Oxygen III line band filters for use in 1.25" and 2" eyepieces, as well as on SCT rear cells.

We have six **Meade** broadband, narrowband, and Oxygen III filters in 1.25" eyepiece and SCT rear cell versions.

We have four **Sirius** contrast enhancement and nebula filters for 1.25" and 2" eyepieces, plus a unique 1.25" *variable* nebula filter.

We have four **TeleVue** Bandmate NebuStar UHC-type narrowband and Oxygen III line band filters in both 1.25" and 2" eyepiece versions.

We have eight **Thousand Oaks** broadband, narrowband, Oxygen III, and H-Beta filters in both 1.25" and 2" eyepiece versions.

Some dealers carry only a few filters to reduce the effects of light pollution. We carry 38. We have one that's exactly right for you.

We have a Meade extended service contract for you.

Meade Sky Assurance Program

You can get a Meade Sky Assurance™ extended service plan from us – *even if you didn't buy your Meade scope from us!*

Sky Assurance™ service contracts extend Meade's standard telescope warranty from one year to your choice of either three or five years. *The service contract even covers normal wear and tear!*

You can enroll for extended service when you buy your telescope, or as late as one month before the expiration of the normal warranty period. In other words, you have eleven months from the date of purchase to decide whether you want to extend your warranty.

Sky Assurance™ contracts are renewable in three or five year increments for as long as you own your telescope. They are even transferable to a new owner, should you sell your telescope while it is covered by a contract. Here's a sample of the 3-year Sky Assurance™ contract prices for some popular Meade scopes.

ETX-90, 3-year Sky Assurance **$64.99**
LX90, 3-year Sky Assurance **144.99**
8"/10" LX200, 3-year Sky Assurance **244.99**
12"/14" LX200, 3-year Sky Assurance **329.99**
16" LX200, 3-year Sky Assurance **1349.99**

Full Meade Sky Assurance™ plan details are available on our website, along with the 3-year and 5-year extended service contract pricing for all Meade telescopes from under $199.99 to $16,999.99.

$399.95 for a 5.1" Mak . . . $798.95 on a mount.

The new **Celestron C130M Maksutov** has a dovetail that will let you install it on a $399 Celestron CG5A German equatorial mount (or on a $749 Advanced Series go-to mount), as well as on a standard photo tripod. You get the best of all worlds – astronomical viewing as well as terrestrial. The C130M has a big 10 x 50mm finder, dust caps, 45° image-erecting diagonal for nature studies (as well as a built-in 90° star diagonal for sky viewing), 32mm 1.25" Plössl eyepiece (64x), soft case, and more. **$399.95**

The Celestron C130M is an easy (and very cost-effective) way to get into the world of precision high power Maksutov optics.

Hot scopes and accessories from William Optics!

$130

How much would you pay for a 97% reflectivity 1/10th wave accuracy 2" enhanced aluminum mirror diagonal with 1.25" eyepiece adapter? Some competitors charge up to $250 for that combination. But the **William Optics** 2" diagonal shown above (our part #W2) is only $130!

A 2" *99% reflectivity* 1/10th wave accuracy *dielectric* mirror diagonal for Schmidt-Cassegrains, with 1.25" eyepiece adapter, costs a total of $360 from a competitor. But the William Optics dielectric diagonal to the right (our #W2DSCT) is only $230!

$230

The 2" rotatable Schmidt-Cassegrain zero image shift Crayford-style manual focuser with a 1.25" eyepiece adapter to the left (our #WSCTF) is only $149. As with all William Optics scopes and accessories, it offers exceptional value – fine optical performance and quality mechanics, at a price less than similar competitive products.

$149

The **William Optics Megrez 80 II APO** *fluorite triplet* 80mm f/6.25 apochromatic refractor optical tube to the right has outstanding optics – truly excellent color correction, very high contrast, tack sharp images – for *$200 less* than a competitive triplet apo that's similarly equipped. It's just another example of the exceptional value of the many unique William Optics products we stock.

$1595

Get your go-to *now.* We ship Celestrons from stock.

Why wait for another manufacturer to build and ship your scope to you? We ship **Celestron Advanced Series** go-to telescopes from *our* stock daily. These full-featured Celestron scopes put multicoated optics on an easy-to-use go-to mount. From a 5" Schmidt-Cassegrain (with optics so good that NASA flies them on the Space Shuttle) to a 10" reflector, there's a Celestron go-to scope that's right for you and your budget. Available scopes include:

a 6" Newtonian reflector **$799.00**
an 8" Newtonian reflector **1019.00**
a 6" achromatic refractor **1069.00**
a 5" Schmidt-Cassegrain **1099.00**
a 10" Newtonian reflector **1199.00**
an 8" Schmidt-Cassegrain **1359.00**
and a 9¼" Schmidt-Cassegrain **1779.00**

Each Celestron Advanced Series go-to has a heavy duty adjustable height tripod with stable 2" diameter steel legs instead of the lighter aluminum legs on competitive scopes. Built-in computers take the guesswork out of finding your way around the skies. They find and track over 45,000 stars and objects for you, compared to 30,000 for the competition. And multicoated optics are standard, not an optional extra.

Celestron C8S-GT 8" go-to

$1359

Sell your used telescopes and accessories quickly *for free* by using the no-charge classified ads at
www.astrofieds.com

Denkmeier Binoviewers are optimized for *your* scope.

Use both eyes to observe through a **Denkmeier Binoviewer**, and you can see up to 40% more detail than you can when looking through a single eyepiece. Your views of the planets, Moon, and deep space objects become almost three-dimensional.

Whether you have a refractor, reflector, or a Schmidt-Cassegrain, there is a Denkmeier Binoviewer with specialized optics that are optimized to give you peak visual performance with your scope's particular optical design. Prices start at $599.

There's nothing mysterious about *this* Sphinx.

The **Vixen Sphinx** telescopes and mounts take the mystery out of go-to astronomy. You don't have to know Messier, NGC, or IC numbers to have your scope find deep sky objects.

Simply move the crosshair cursor over the object displayed on the Star Book hand control's 4096-color LCD star chart screen. Push a button and the Sphinx mount moves to that object. Zoom-In/Out buttons for the star chart display also control the motor speed. As you zoom in on an object displayed on the screen, the motor speed automatically slows for more accurate control. Zoom out and the motor speed increases to cover large distances more quickly.

Vixen Star Book hand control showing star chart display

The Star Book's 4MB flash ROM memory can be updated from the Internet to keep you current with the heavens. And the easy-to-use Star Book can be used as a stand-alone star atlas to let you learn the skies anywhere, anytime.

The Sphinx go-to mount with Star Book controller is available separately for use with your own optics. It is also available in premium Vixen telescope/mount packages that range from a 3.1" f/5 refractor on a supremely portable tabletop go-to mount to big 8" reflectors and catadioptrics on full length field tripods.

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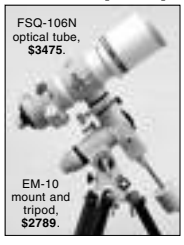

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Barnard's Milky Way

More than 75 years after it was published, Barnard's photographic atlas of the Milky Way remains the definitive work on dark nebulae. /// BY MICHAEL E. BAKICH

Fifty photographs. That's all it took to make a classic. *A Photographic Atlas of Selected Regions of the Milky Way* by E. E. Barnard is one of the benchmark publications in the history of astronomy — and it's also one of the most sought-after works by astronomy book collectors. Yet *Selected Regions* (as it is known) contains just fifty photographs, a total that any active astrophotographer today can produce in less than a month. So what's the big deal?

The answer involves when and how the photographs in *Selected Regions* were made, what they show, and how copies of the atlas were put together.

THE MILKY WAY and its mysteries attracted E. E. Barnard's attention over much of his career. YERKES OBSERVATORY

The man responsible for *Selected Regions* has been called the greatest visual observer who ever lived. Edward Emerson Barnard was born on December 16, 1857, in Nashville, Tennessee. Barnard's childhood was spent in abject poverty — before the age of nine, he took a job to help support his mother. Luckily, the place where he found work was a photographic studio, and the training he received served him well. The job also gave him chances for self-schooling, which he avidly pursued as astronomy more and more absorbed his interest.

At the peak of his career, Barnard worked at the two most prestigious American observatories of his time. He was at Lick Observatory, located on Mt. Hamilton, California, from 1888 to 1895, and at Yerkes Observatory, in Williams Bay, Wisconsin, from 1896 until his death in 1923. During his life, Barnard discovered seventeen comets, including the first photographic discovery of one on October 12, 1892. He published more than nine hundred scientific papers, received eight major astronomical awards, and made the last visual discovery of a planetary satellite on September 9, 1892. The news of this discovery — a fifth moon orbiting Jupiter, soon named Amalthea — electrified

RHO (ρ) OPHIUCHI lies at the hub of perhaps the grandest cloud of dust and gas Barnard photographed. Compare his Plate 13 with a modern color image [inset]. (Exposure: 4h 30m on April 5, 1905) ALL BLACK-AND-WHITE SKY IMAGES FROM *SELECTED REGIONS*; INSET: MARCO LORENZI

THE RICHNESS OF THE BACKGROUND STARS in Plate 41 helps reveal threads and clouds of dust that dwell in the vicinity of the bright star Altair in Aquila (lower left). (Exposure: 4h 5m on August 27, 1905)

both the astronomical world and the general public and turned Barnard into an instant astronomy celebrity.

Work of a lifetime

Selected Regions was his greatest work, and its publication came about through a grant in 1907 from the Carnegie Institution of Washington. But because Barnard was working on another project at the time and because he insisted that the book's photo reproductions should faithfully represent the originals, the atlas was not printed until 1927. How demanding was Barnard? He required that photographic prints (made from the original plates) be bound into each volume, and he personally inspected every print of the 35,700 needed for the seven hundred copies of *Selected Regions*.

Barnard died on February 6, 1923, and others had to finish his work. The two people most responsible for producing *Selected Regions* were Barnard's niece and personal assistant, Mary Rhoda Calvert, and Yerkes Observatory's director, Edwin Brant Frost.

The atlas appeared in two volumes: Part 1, Photographs and Descriptions; and Part 2, Charts and Tables. The images contained in the pages of Part 1 were taken during a twelve-year period, although the majority were made during one eight-month stretch in 1905. The earliest photograph was made on September 15, 1904, and the last was taken on September 24, 1916.

In addition to the fifty photographic plates contained in *Selected Regions,* Barnard included a fifty-first plate that shows nine areas of the Milky Way on a small scale. The circular images on this plate were taken through a 1.6-inch f/4 stereopticon lens riding on the mounting of the telescope. Barnard selected nine photographs to represent the most interesting and important regions of the Milky Way — those showing structures and cloud forms. The field of view for each image is 23.2°, and all show portions of the Milky Way visible on summer evenings.

Part 2 of *Selected Regions* is a companion volume that provides maps showing the area of each photograph. This volume

DARK MASSES OF DUST litter the plane of the Milky Way. Barnard's careful photography helped astronomers accept that these dark patches weren't just starless voids. MARCO LORENZI

is a welcome addition for observers who want to view the objects. The maps have a grid of celestial coordinates (epoch 1875.0) corresponding to each photograph. Calvert made each map under Barnard's supervision and later outlined the regions of dark nebulosity, inserting their catalog numbers.

Making the photographs

Work on *Selected Regions* began in 1897, when Barnard contacted Catherine Wolfe Bruce (a wealthy patron of astronomy), asking her to fund a photographic telescope with which he could continue his studies of the Milky Way. The result — the Bruce photographic telescope — combined 10-inch and 6-inch wide-field photographic refractors plus a 5-inch guide scope, all carried on a single mount. The telescope was housed in a small dome on the grounds of Yerkes Observatory, and Barnard started using it in April 1904.

In 1905, Barnard traveled to Mount Wilson Observatory, near Pasadena, California, to photograph the more southerly sections of the Milky Way that were hard to capture from the latitude of Yerkes. He spent eight happy months at Mount Wilson, making hundreds of photographs. Forty of the fifty photos in *Selected Regions* were taken at Mount Wilson, compared to only ten from Yerkes. The exposure time for the plates averaged 4 hours 8 minutes each. The shortest exposure was 50 minutes (Plate 9, "Region in Gemini, southeast of M35") and the longest lasted 8 hours 40 minutes (Plate 11, "Region in Scorpius and Libra"). This exposure was taken over two nights.

THE SCORPION'S CLAWS lie in a star-strewn field near Delta (δ) (upper left) and Pi (π) Scorpii in Plate 11. None of Barnard's dark objects lie within this plate's field. (Exposure: 8h 40m on April 29 and 30, 1905)

SWIRLING LANES OF DUST located north of Theta (θ) Ophiuchi curl through Plate 19. In his description of this plate, Barnard wondered why these dark "markings" didn't have the same shapes as luminous nebulae. (Exposure: 3h 30m on May 8, 1905)

STAR CLOUDS IN SCUTUM CONTRAST with an almost tangible darkness in Plate 36. Barnard noted that the dark region north of globular cluster M11 (lower center) was "full of dark structures which are mostly lost in the printing." (Exposure: 4h 30m on August 4, 1905)

To increase the contrast of the printed images, Barnard had the darkroom technician use a double-negative process. The original plate was used to make a contact (same-size) positive image on photographic film. A second negative image was made from the positive. Finally, the second negative was sandwiched with the original negative to make the final prints.

Statistics

During his life, Barnard produced two lists of dark nebulae. The first contained 182 entries, but they were numbered only to 175. The discrepancy is explained by noting that Barnard added seven "extra" numbers: B44a, B67a, B83a, B84a, B117a, B119a, and B131a. Three objects in this list, namely B52, B131a, and B172, are actually duplicates. The first of Barnard's lists, therefore, contains 179 objects.

The second list by Barnard is more straightforward. Beginning at B201 and ending at B370, it totals 170 objects. Together, the two lists mention 349 dark nebulae. Thirty-two of these do not appear in *Selected Regions*. Most of the nebulae not shown on the maps have far northern declinations and were out of the fields of view of the photographs. Interestingly, the most famous dark nebula of all — the Horsehead Nebula (B33) in Orion — fell outside the view of Barnard's camera and does not appear in *Selected Regions*.

Slow realization

When Barnard first began to photograph the Milky Way, he stood with most astronomers in believing dark areas were starless voids. As he took large numbers of photographs of the Milky Way, however, Barnard began to question this.

In the January 1916 *Astrophysical Journal*, Barnard described an observation made three years earlier: "I was struck with the presence of a group of tiny cumulous *[sic]* clouds scattered over the rich star clouds of Sagittarius. They were

Michael Bakich *is an associate editor of* Astronomy.

MOST FAMOUS of the Barnard objects, the Horsehead Nebula (B33) in Orion, lies too far from the Milky Way to appear in *Selected Regions*. ROBERT GENDLER

remarkable for their smallness and definite outlines — some not being larger than the Moon. Against the bright background they appeared as conspicuous and black as drops of ink. They were in every way like the black spots shown on photographs of the Milky Way, some of which I was at that moment photographing. One could not resist the impression that many of the black spots in the Milky Way are due to a cause similar to that of the small, black clouds mentioned above — that is, to more or less opaque masses between us and the Milky Way."

In his introduction to *Selected Regions*, Barnard presents a strong case for the existence of dark nebulosity. He gives examples of obscuring material visible directly, that is, in front of a brighter background, and states, "there need be no hesitation in accepting the fact that such bodies exist."

Barnard's *Selected Regions* laid the foundation for understanding the true nature of dark nebulae. These areas weren't "great cavities or vacancies," as claimed by the famed English astronomer William Herschel. Rather, they are made of vast amounts of dust and cold gas, and some have protostars beginning to form in their depths. This dark material obscures light from brighter objects behind it and produces some of the most amazing sights in the sky. Many of these objects now bear the designation given them nearly a century ago by one of the greatest observers of all time, Edward Emerson Barnard. A

For more about Barnard's nebulae, see www.astronomy.com/toc

WISPY NEBULOSITY wraps around the bright stars of the Pleiades, reflecting their blue-white starlight, in Plate 4. (Exposure: 3h 48m on September 7, 1905)

THE NORTH AMERICA NEBULA has become familiar to skywatchers, but in Barnard's day, it was much less well known. His Plate 46 barely captures its fainter companion, the Pelican Nebula, on the right. (Exposure: 4h 20m on September 4, 1905)

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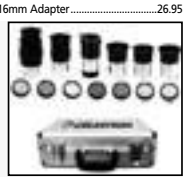

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Relocating Hubble, sniffing Mars, and transits of martian moons

PLANE CHANGE FOR HUBBLE

Why doesn't NASA attach the Hubble Space Telescope to the International Space Station (ISS) to service the telescope safely? Is that technically feasible?

— **FRANCISCO DA FONSECA,** RODRIGUES, CAMPINAS, BRAZIL

MOVING HUBBLE to the International Space Station for repairs simply cannot be done with existing spacecraft because the two objects occupy such different orbits. NASA

Of all orbital maneuvers, altering a spacecraft's orbital plane requires the greatest change in velocity and consumes the most fuel. The orbital inclinations of Hubble and the Space Station differ by a minimum of 23.1°. To move Hubble into the ISS orbit, we would have to change the telescope's speed by about 3,000 meters (9,800 feet) per second. To put this number into perspective, consider that it amounts to about 40 percent of the speed needed to keep Hubble in orbit at all. The space shuttle has the ability to change velocity by 700 meters (2,300 feet) per second in orbit, so the short answer to your question is no. Even the shuttle doesn't carry enough fuel to do the job. — **BILL COOKE,** MARSHALL SPACE FLIGHT CENTER

A WHIFF OF MARS

I've read that Moon-walking Apollo astronauts said lunar dust on their space suits smelled like spent firecrackers. When humans go to Mars, do we have any idea what Mars dust might smell like? — **DAVID REYNOLDS,** LEBANON, TENNESSEE

Our best guess from the Mars Global Surveyor Thermal Emission Spectrometer (TES) data is that martian dust is fine-grained material (less than 10 microns across), mostly composed of silicate minerals. These are the minerals that make up most rocks on Earth. The TES spectra show an infrared absorption band that matches the mineral plagioclase, which is commonly found in volcanic rocks.

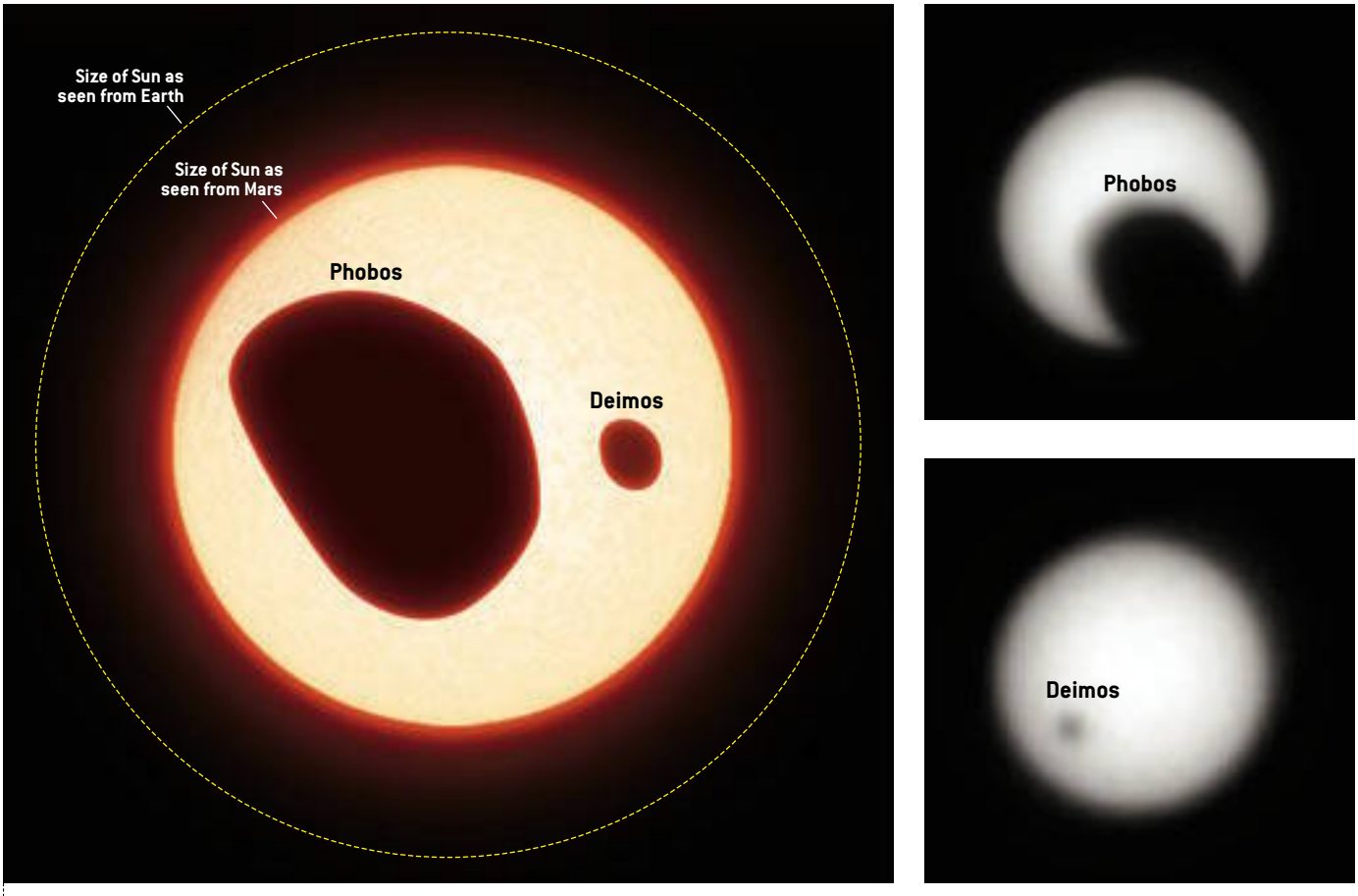
Overall, we can match the TES spectra with ground-up basalt, the type of lava found on Earth's ocean floor, in Hawaii, Iceland, and some places on the continents. Recent analysis of TES data shows the presence of very small amounts of carbonates — minerals that form from the interaction of rock with water. Analysis of soil from the Viking, Pathfinder, and now the Mars Exploration Rover sites reveals the presence of large amounts of sulfur (5 to 10 percent), but we don't know yet what mineral the sulfur is in.

Unfortunately, none of this helps much with the question of smell. Very small amounts of highly aromatic molecules typically cause odors, and we don't yet have the ability to detect them in the martian soil. — **PHIL CHRISTENSEN,** ARIZONA STATE UNIVERSITY

MOON SHADOWS

Are either of the moons of Mars large enough to eclipse the Sun as seen from the surface of Mars? — **PAUL MANCUSO,** MILPITAS, CALIFORNIA

Although both moons orbit Mars much closer than our own Moon orbits Earth, they also are very small: Phobos measures only 12 miles (19 kilometers) across and Deimos is half that. Their apparent sizes to an observer on the surface of Mars are 11' and 2', respectively. The Sun itself spans 21' on average, which means that neither



MARS ROVER OPPORTUNITY observed the martian moons Deimos (bottom right) and Phobos (top right) when they transited the Sun earlier this year, on March 4 and 7, respectively. The diagram shows the two moons in proportion to the Sun, which itself appears about one-third smaller from Mars than it does from Earth. When see at full phase and near the zenith, Phobos would shine at about magnitude –9 and Deimos near –5. Another type of eclipse occurs when the moons pass into the shadow of Mars. Phobos also can occult Deimos. NASA/JPL/CORNELL; ILLUSTRATION: *ASTRONOMY*: ROEN KELLY

moon is capable of blotting out the entire solar disk. So while these events are sometimes referred to as eclipses, they are technically transits.

But that doesn't mean they are uninteresting or unimportant. During transits of Phobos, sunlight intensity on Mars would drop by up to a quarter, while the spectacle itself would resemble a partial or annular eclipse. Transits of Deimos would be reminiscent of the rare transits of Venus as seen from Earth, such as the one that occurred this past June. These are fleeting events that last only a few tens of seconds, but you typically would expect to see several during a period of two weeks. The exact number would depend on your latitude and the martian season.

In fact, the British-built Beagle 2 lander that disappeared late last year would have observed several Phobos transits to help it figure out exactly where it came down on the martian surface. The shadow of Phobos "scans" the Martian disk, gradually moving farther south at the end of northern hemisphere winter. It passed through the likely latitude of Beagle 2 in early February 2004 and crossed the martian equator at the spring equinox in March.

Spirit and Opportunity, whose locations on Mars are already well known, are in the process of observing several of these transits using their panoramic cameras to refine our knowledge of the moons' orbits. This marks the first time a transit of the Sun by a moon has been imaged from the surface of another planet.

Both Phobos and Deimos can be eclipsed by the shadow of Mars, a situation analogous to lunar eclipses we see from Earth. Because Phobos revolves around Mars much faster than Mars rotates, it appears to rise in the *west,* race across the sky for about 4 hours, and then set in the *east*. Phobos would disappear in seconds as it entered the shadow cast by Mars, and it would remain in eclipse for about an hour. Deimos, on the other hand, takes about two-and-a-half martian days to move across the sky and could remain eclipsed for up to 2 hours. At times near the martian equinoxes, both moons experience eclipses on every night they are visible and on every revolution they make.

Moreover, Phobos can eclipse Deimos, although technically such an event would be called an occultation. Phobos eclipses of Deimos can be seen only from a narrow band of latitudes near the martian equator.

— APOSTOLOS CHRISTOU, ARMAGH OBSERVATORY

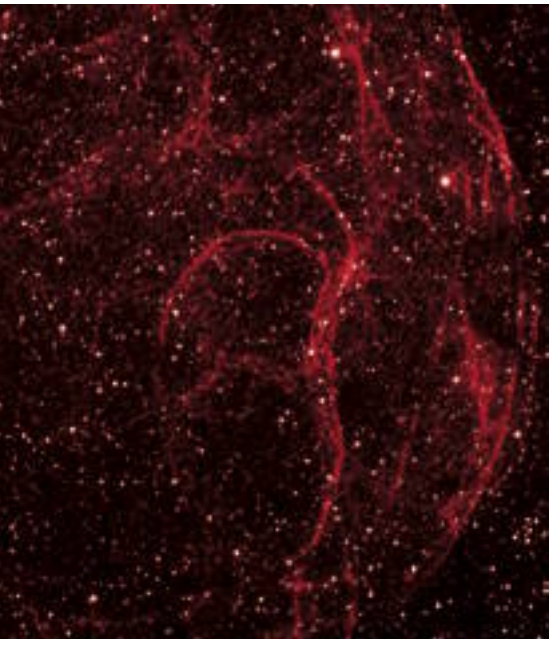
Undaunted by the elements and high altitude, two amateur astrophotographers took their craft to the summit of Mauna Kea. /// BY LISA JOHNSTON WITH JOHN SEFICK

Extreme imaging

A skateboarder attempts a 180 kickflip

20 feet in the air with nothing to catch him but the concrete below. The snow packs down under the weight of a skier landing a remarkable corkscrew 540. Coastal onlookers are captivated as a body boarder pulls a reverse 360 aerial just as the water breaks. Parka-clad figures fight the chilling wind as they approach the top of the summit; loaded down with equipment and struggling to adjust to the atmospheric pressure, they prepare for a long night ahead — of stargazing.

All right, so astronomy probably won't become the next event in the X Games, the annual extreme-sports competition, but lately, with cities growing larger and light pollution growing stronger, astronomy thrill-seekers have pushed the search for clear skies to the edge. One such observer, native Chicagoan John Sefick recently decided to take his passion to a new level, literally. In December 2002, I had the privilege of accompanying my friend to a place many would call an astronomer's paradise: Mauna Kea. John took his passion for hydrogen-alpha CCD imaging high above the clouds of Hawaii in search of the clearest sky in the world.



SUPERNOVA REMNANT SIMEIS 147 in Taurus shrouds a pulsar, another artifact of the gigantic explosion some 100,000 years ago that created the nebulosity. JOHN SEFICK AND LISA JOHNSTON

An astronomy haven

Towering high above the palm trees on the Big Island of Hawaii, Mauna Kea offers more than 300 crystal-clear nights each year and negligible levels of humidity. This extinct volcano reaches 13,796 feet (4,200 meters), which means 40 percent less atmosphere than at sea level. The reduced atmospheric absorption allows more light to pass through to sensitive CCD cameras, greatly improving image quality and detail like no other place on Earth. Mauna Kea is open year round, and the Visitor Information Station, located below the summit at 9,200 feet (3,000m), offers exhibits, presentations, and nightly star parties to the public free of charge. The incredibly dark sky and informative public outreach program make Mauna Kea the number one astronomy destination in the world.

So if Mauna Kea is such a great place for astronomy, why aren't more people outside the professional community dragging their scopes to the top? Unfortunately, a considerable amount of risk is involved. On the summit, extremely hazardous conditions like 70-mile-per-hour (113-kilometer) winds, nightly freezing temperatures, flash snowstorms, low oxygen levels, and the possibility of altitude sickness loom. Such elements are dangerous to people who are not physically up to the challenge. In fact, the numerous tour vans that drive to the summit are equipped with oxygen tanks for tourists who come seeking the perfect sunset photo and find not only the view but also the altitude breathtaking. The difficulty in acclimating to such drastic elevations is by far the main reason this location is geared for only the serious extreme-astronomer.

Preparing for the extreme

Before John and I flew to Hawaii, he put a considerable amount of planning into this expedition. Luckily for me, John is no newcomer when it comes to exotic imaging destinations. With his equipment in tow, John frequently travels to Australia to capture the dark southern sky, and he spends a good portion of his time imaging in the deserts of New Mexico. Naturally, Mauna Kea was the next step toward achieving the best sky conditions for his artistry. First, he needed to determine where to stay on the island, how to get to and from Mauna Kea safely, and how to prepare for the weather conditions and drastic altitude that awaited us. Advance planning turned our trip to Hawaii into a successful imaging expedition.

Ideally, the best place to stay while imaging on Mauna Kea would be near the mountain itself, where the action is. A sea of lava rock from ancient volcanic eruptions, however, surrounds Mauna Kea, making the barren landscape look more like Mars than a tropical paradise. Perhaps if our slumber were as adventurous as our stargazing, we would have popped a tent

AT 13,796 FEET (4,200 meters) above sea level, the summit of Mauna Kea lures professional and amateur astronomers alike. The mountaintop is home to a number of research telescopes, including the twin Kecks, the largest optical telescopes in the world, and the Canada-France-Hawaii telescope (see "Mauna Kea's colorful universe" on page 34). To capture wide-angle images, astrophotographers John Sefick and Lisa Johnston used an SBIG ST-10 CCD camera with a hydrogen-alpha filter and 300-millimeter Canon telephoto lens atop a Takahashi EM-200 equatorial mount and a wood tripod. JOHN SEFICK

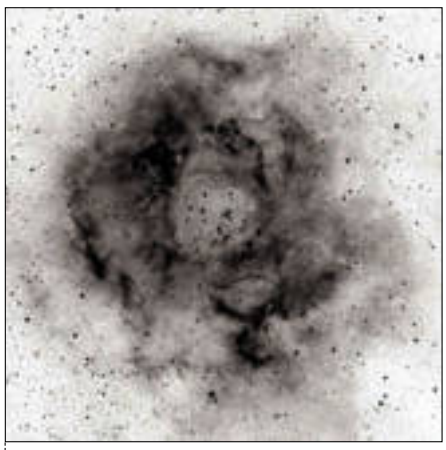
in the state park at the mountain's base. Instead, we opted for the next closest accommodation, a hotel in Hilo. The one-hour drive from the summit to Hilo was worth the extra comfort after a long night of observing.

Travel to and from the summit requires a four-wheel-drive vehicle. The steep road is only partially paved, and the hairpin turns are difficult to manage, even during daylight. Most car-rental agencies don't allow their vehicles to travel to Mauna Kea, and almost all of them strictly prohibit driving to the summit. We found a truck-rental company, however, that does not mind frequently replacing brake pads, and they had four-wheel-drive vehicles that were up to the challenge.

Finally, before we left the mainland, we tried to prepare for weather conditions on the summit. It seemed strange that packing for the Hawaiian Islands included earmuffs and parkas, but the best plan was to expect the worst. Astonishingly, it never snowed while we were on the summit, but snow is not uncommon there, and the brutal winds can give the air a sub-zero feeling. The elevation effects were particularly difficult, but bringing along some food and water kept any altitude sickness at bay. Also, controlling the CCD camera from a laptop inside the heated vehicle made the frequent outings to the telescope tolerable.

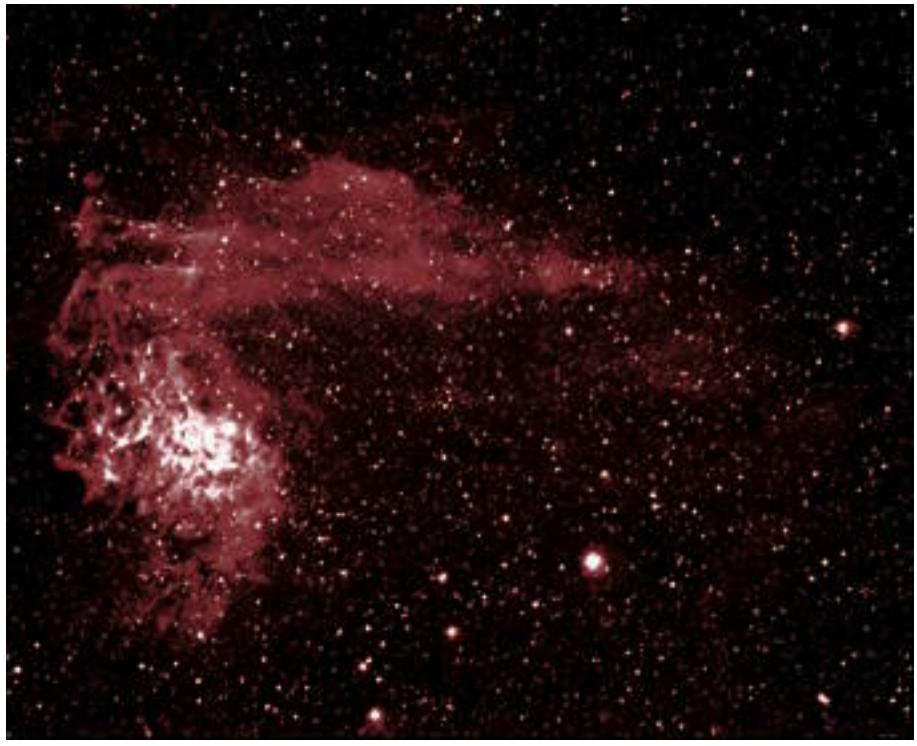
Equipment and setup

For this expedition, the goal was to capture wide-angle images of bright hydrogen regions, such as the Horsehead Nebula in Orion and supernova remnant Simeis 147



THE ROSETTE NEBULA (NGCs 2237–9) in Monoceros lies about 5,000 light-years from Earth and spans approximately 100 light-years. An open cluster of young stars lies at its center. This negative image highlights the nebula's complex shape. JOHN SEFICK AND LISA JOHNSTON

THE HORSEHEAD NEBULA, part of a larger molecular cloud in Orion, has been shaped by interstellar winds. JOHN SEFICK AND LISA JOHNSTON



THE FLAMING STAR NEBULA (IC 405), which lies about 1,500 light-years from Earth, is located in Auriga and covers roughly 5 light-years. AE Aurigae is the bright star illuminating the surrounding gas and dust. JOHN SEFICK AND LISA JOHNSTON

in Taurus. The setup on Mauna Kea, therefore, needed to reflect our expectations for the images as well as the restrictions of the environment. Because conventional photographic film requires long exposures, which would be nearly impossible to acquire while on the summit, using CCD technology was the best approach. For the optics, we tried to keep the size small. Large scopes may be prone to unsteadiness caused by strong wind currents, so John brought along a 300-millimeter Canon telephoto lens adapted for a drop-in hydrogen-alpha filter. This setup is perfect for high-altitude observing because its minimal surface area easily resists ravaging winds, and its short focal length offers a wide-angle view of the sky. Also, the 4-inch aperture could capture large hydrogen objects perfectly without compromising their fine details.

It was important to choose equipment that met our imaging needs, but a strong tripod and sturdy mount were the crucial components for successful imaging. We had no problems keeping our 40-pound Takahashi EM-200 equatorial mount steady, and with a built-in polar-alignment scope, setting up in the frigid environment was a swift process. Our tripod, standing 4 feet high on non-collapsible wooden legs, kept our system in place.

With a solid apparatus, obtaining the ultimate astronomical images was easy using a Santa Barbara Instruments Group ST-10 CCD camera. This device has a maximum area of 2,184x1,472 pixels, the perfect field of view for framing large objects such as the Veil Nebula (NGCs 6992–5) in Cygnus or Barnard's Loop in Orion. Powering our camera and mount was a 12-volt marine battery. Things we tried to avoid were bulky, hard-to-manage mounts and time-consuming polar alignments. In the low-oxygen environment, it's very difficult to concentrate on precise adjustments, so the faster we could set up our equipment, the better.

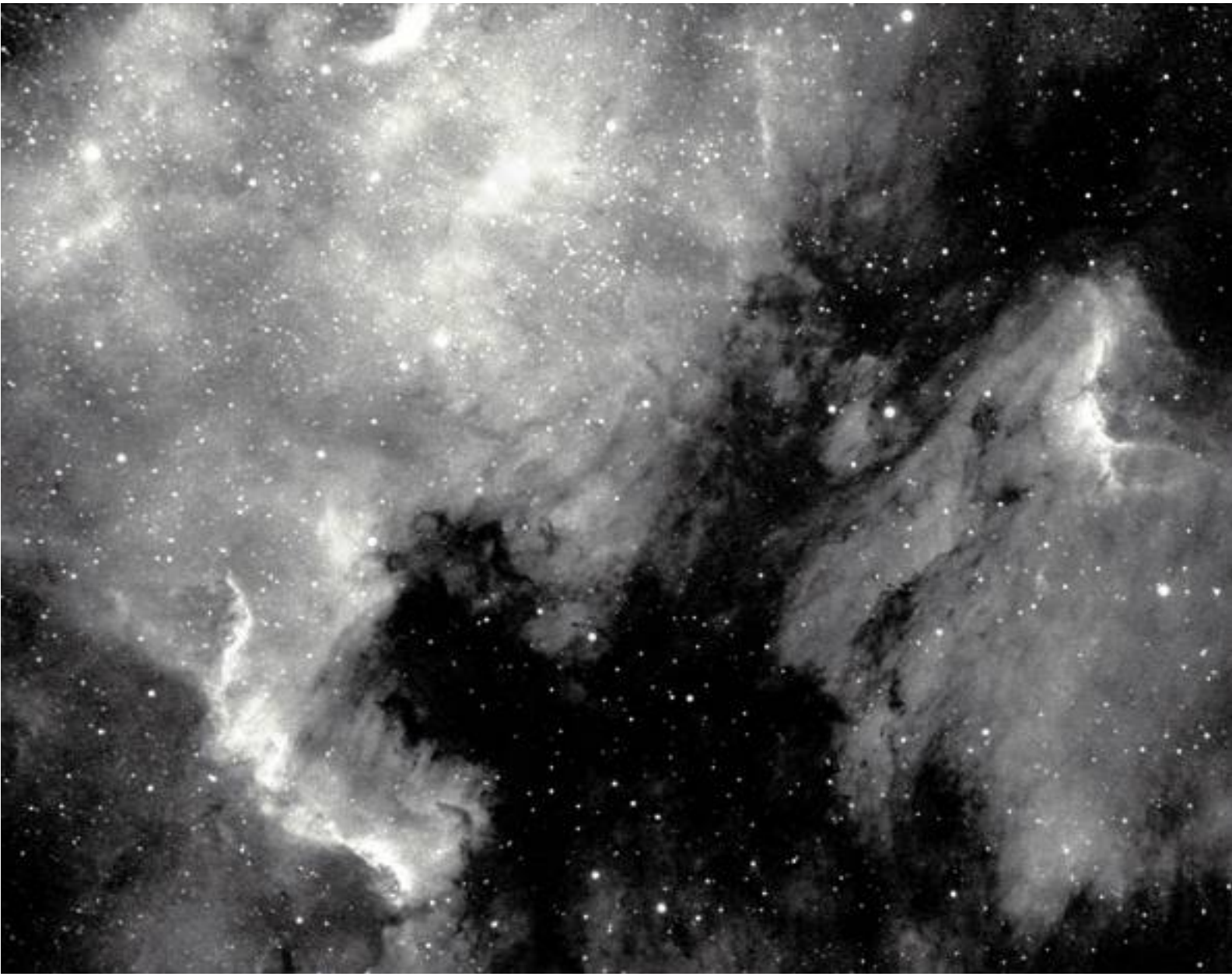
Imaging above the clouds

After in-depth planning, assessments of our physical abilities, and trial runs with the equipment, it was time to go to work. We imaged at the summit, near the University of Hawaii's observatory. The only difficulty being so close to the road was the occasional passing car, but generally, drivers on the summit are courteous enough to dim their headlights before approaching the observatories.

IC 1396 IN CEPHEUS is one of the largest emission nebulae in the sky. Hot, young stars ionize the dense cloud's hydrogen, making it glow. JOHN SEFICK AND LISA JOHNSTON

Most of our images were composites of three or four 6-minute exposures. All exposures were reduced with a dark frame, and none required flat-field subtraction. With the bitter cold and the slowing effects of high altitude, we averaged about two complete composites per night. Some of our best photographs were the California Nebula (NGC 1499) in Perseus, which shows a brilliant quality through a hydrogen-alpha filter, and the

Lisa Johnston *spent her last adventure in the French Alps observing the 2004 Venus transit.* **John Sefick** *has returned to Mauna Kea to film other people searching for darkness.*



THE NORTH AMERICA AND PELICAN NEBULAE (NGC 7000) in Cygnus are separated by a dark absorption cloud. The gas clouds lie 1,500 light-years from Earth and together stretch across approximately 50 light-years. JOHN SEFICK AND LISA JOHNSTON

mysterious Flaming Star Nebula (IC 405) in Auriga. When compared to other images, even those taken in the dark sky of New Mexico, the images captured at Mauna Kea have more defined detail and precision clarity than images taken at lower elevations. The pristine seeing conditions of Mauna Kea reveal the full beauty of objects.

John and I also imaged near the Visitor Information Station. There, on the southern side of the mountain, areas lower than the summit are subject to polar-alignment difficulties. A few other places exist at this level where imaging is possible, and we found an area located off an access road across from the visitor center. By comparison, the lower elevation was not as cold as the summit, and in some darker areas, the image quality was very competitive. However, the thrill of imaging closer to the stars than ever before is achieved only at the very top.

To the edge and back

Mauna Kea is the ultimate location for hydrogen-alpha imaging, but while the high altitude and freezing temperatures may be advantageous for your CCD camera, they can make for a hostile work environment and be dangerous to your health. Like any risky expedition, it is crucial to be accustomed to your equipment and to understand your physical limitations. With that said, there is nothing quite like standing on top of a volcano, under more stars than you ever could imagine, and feeling, well, cold. But underneath the cold, the adrenaline is pumping and a triumphant feeling of success is building. Imaging on Mauna Kea is the ultimate astronomy adventure, and while it may never become a video game like other extreme sports, it will remain an unforgettable experience. A

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AMATEUR ASTRONOMY

Now in its sixth decade, the Astronomical League is still going strong.

/// BY JACKIE BEUCHER

A League of its own

These days, I suppose folks interested in astronomy first find out about the Astronomical League by surfing the Internet. But in 1983, when I decided to get involved in astronomy, I heard about the League after joining a local astronomy club, the Astronomical Society of Kansas City. I had always been an armchair astronomer, but I'd heard Halley's Comet was coming in a few years. I wanted to know more about astronomy and even own a telescope. So I bought a 4-inch reflector and, yes, I saw Halley's Comet through it.

But one dark night when I was out observing with other members of the club, someone handed me a list of Messier objects and a few blank observation forms. I was told that if I observed all 110 Messier objects, I'd get a certificate and a pin from a group called the Astronomical League. This sounded great to a one-time Girl Scout, so my quest began. It took a few years, but I was one proud observer when I was presented with that pin. I also discovered the League had all sorts of observing awards and, while working on them, I could learn quite a lot about navigating through the night sky.

At that time, the League was a large organization "out there" that the Kansas City club belonged to, but I knew little more about it. After spending the last ten

THE ASTRONOMICAL LEAGUE, through its many clubs and satellite organizations, hosts many star parties throughout the United States. The ASKC Star Party in Marion, Kansas, is shown here. TOM MARTINEZ

years working for the League as a national officer, I've realized the perception of the organization is still nebulous for too many amateur astronomers. Having grown to love the Astronomical League, allow me to introduce it to you.

An umbrella organization

Bringing groups of amateur astronomers together is really what got the League going. The League was founded in 1941 by a group of amateur astronomy societies in the northeastern United States. The idea was discussed at the 1939 World's Fair in New York City, and by November 1941, twelve societies had ratified the new bylaws of the "Amateur Astronomers' League of America." World War II intervened, but in 1946, the League was reborn. Annual dues were 15¢ per club member. The eminent Harvard astronomer Harlow Shapley was the interim president in July 1947 for the first convention, which launched the renamed Astronomical League with 1,568 members and $67.52 in its treasury. An amateur astronomer, Ed Halbach, was elected the first president of the League. The organization has come a long way since then. Our treasury and trust fund now contain roughly $150,000.

The League consists of more than 290 astronomy clubs and a large number of members-at-large, for a total of approximately 20,000 individual members. The group's stated mission is to promote the science of astronomy by fostering astronomical education, by providing incentives for astronomical observations and research, and by assisting communication among amateur astronomical societies. Just how does the League accomplish all this?

In some cases, member clubs host star parties. In 1999, I made my first trek to the Texas Star Party, held in the Davis Mountains of West Texas each spring. Hundreds of amateur astronomers gather there to observe under a magnificently dark night sky all week long. Highlights include guest speakers and astronomy vendors, and everyone who attends is an astronomy nut, just like me. It's heaven on Earth for us. The Texas Star Party is the

Jackie Beucher *is past president of the Astronomical Society of Kansas City. She serves as executive secretary of the Astronomical League.*

GARY FUJIHARA (left) was the recipient of the Astronomy Day award at ALCON 2002 in Salt Lake City, Utah. Fujihara is the founder of the Astronomy Day Institute in Hilo, Hawaii. Astronomical League president Bob Gent stands at right. JACKIE BEUCHER

MAXWELL MOE AND KAYLA LA FRANCE were presented awards at ALCON 2003 in Nashville, Tennessee. Moe won the National Young Astronomer Award. La France was the recipient of the Jack Horkheimer Award, for exceptional service by an astronomer under the age of nineteen. JACKIE BEUCHER

ASTRONOMICAL LEAGUE BULLETIN

THE *REFLECTOR* has been a publication of the Astronomical League for more than 55 years. The first issue, seen here, was comprised of only two pages printed back-to-back on one sheet. It's currently a multi-page, full-color publication sent to 20,000 members. ED FLASPOEHLER

GREG PIEPOL, a member of the Northern Virginia Astronomy Club, won the Astronomical League's first national Webmaster Award at ALCON 2003. JACKIE BEUCHER

AWARD RECIPIENTS GATHER at ALCON 2003 in Nashville. From left to right, the winners are Paul Comba, Katie Moore, Maxwell Moe, Ryan Hannahoe, and Kayla La France. BOB GENT

/// ASTRONOMICAL LEAGUE AWARDS

THE LEAGUE is big on awards. If there's something in the universe of amateur astronomy that needs to be acknowledged as the best, the League wants to know about it. The annual awards are listed below.

The National Young Astronomer Award
$4,000 telescope and a lifetime pass to McDonald Observatory, Fort Davis, Texas. Sponsored by Meade Instruments.

The Jack Horkheimer Award
$1,000 award for service to astronomy. Sponsored by Jack Horkheimer, the Star Gazer.

The Bob Wright Award
for service to the Astronomical League.

The President's Award
for service to amateur astronomy.

The Leslie Peltier Award
for outstanding astronomical observing.

The Mable Sterns Award
for the best League newsletter.

The Webmaster Award
for the best League web site.

regional event for the Southwest region of the Astronomical League. Other star parties such as Stellafane, the Table Mountain Star Party, Astrofest, the ICSTARS Star Party, the Nebraska Star Party, the Okie-Tex Star Party, the Northeast Astronomy Forum, the Starry Nights Festival, and the Winter Star Party all are run (or were founded) by either League clubs or regions. If one of the ten regions of the League does not host an annual star party, it offers a regional meeting of some sort. These are all good ways to get regional clubs together to trade ideas or just to socialize.

Observe!

Observing "clubs" — programs to encourage individual observations — have become a major activity among League members. Just as I found out so many years ago, giving new amateur astronomers lists and goals gets them out under the night sky. The first observing award the League adopted, in 1967, was the Observe the Messier Objects Award, begun by members of the Omaha (Nebraska) Astronomical Society. Amateur astronomer George Allen of Omaha originated the idea of giving a pin as part of the award. As Allen said, "I figured if a pin worked to get me to attend church, then it might get new members to tackle the Messier objects, thereby getting them to know the skies, their telescope, star atlases, and some mythology." The rest is history. The Messier pin now proudly adorns the clothing of many amateurs across the country.

Another significant award program focuses on the Herschel objects — all 400 of them. The Ancient City Astronomy Club in St. Augustine, Florida, developed this award. Soon to follow were awards for observing the Sun and meteors. John Wagoner of the Texas Astronomical Society of Dallas introduced binocular astronomy awards to the League. More than twenty "Observe" awards now exist for objects such as the Moon, planets, galaxy clusters, double stars, asteroids, and more. The latest League Observe awards are the Sky Puppy (for our young observers), the Southern Skies Telescopic, and the Constellation Hunter. On the drawing board are clubs for star clusters and local galaxy clusters. These awards stir the interest of amateur astronomers and achieve the League's mission of promoting astronomy, one observation at a time.

Other activities

What about Astronomical League members who do not actively observe? The organization offers many other benefits such as its quarterly magazine, the *Reflector*. This magazine presents news by and for League members. Articles in the *Reflector* highlight League club activities, spotlight upcoming astronomical events, offer observing tips, present book reviews, and provide an outlet for member feedback. Bob Gent, the

THE ISS-AT is a collaboration between the Astronomical League and NASA to place a telescope that can be used by amateurs aboard the International Space Station. A test model of the telescope has been constructed and resides at the Arizona Sky Village in Portal, Arizona. Project team members are (left to right) Rocky Alvey, A. G. Kasselberg, Jack Newton, Alice Newton, Terry Mann, Leigh Anne Johnson, Gene Turner, and (kneeling) Bill Williams. JACKIE BEUCHER

THE ALPHA TELESCOPE of the ISS-AT project is a 14-inch Celestron Schmidt-Cassegrain optical tube assembly operating at *f*/7. A new version of this scope will be installed aboard the International Space Station in 2006. JACKIE BEUCHER

current editor-in-chief, has assembled a staff of volunteer associate editors who help with the many tasks involved in publishing this popular quarterly magazine.

The League offers a book service. League members can purchase any astronomy book published at a 10 percent discount, with no shipping charges.

League members can attend national conventions, or ALCONs. These annual meetings are a highlight of my year because something really special always happens. The 2004 convention will take place in Oakland, California.

How many astronomy clubs celebrate Astronomy Day every spring? We're aware of hundreds of them. The League began promoting this national event in 1980, and Astronomy Day activities become larger and better every year.

As the League grows, we gain some notoriety. People learn about the organization and come to us with their ideas and projects. A few years ago, the League was asked to head a project that would place an amateur telescope on the International Space Station. The first version of this telescope, the ISS-AT, is up and running, and if all goes according to plan, a new version will be installed on the ISS in 2006.

The League as a whole strongly advocates reducing light pollution. Bob Gent, League president, is a man driven to fight bright night skies. He serves as the League's liaison to the International Dark-Sky Association (see "Reclaim the night sky," *Astronomy*, June 2004, for more on this organization). Gent has presented his case for preserving dark night skies all over the country.

The League represents different things to different people. Until recently, the organization consisted of a couple dozen volunteers spread across the United States, each working from their homes.

Now the League has a national office, which opened in Kansas City, Missouri, in 2003. A generous group of Kansas City businesses donated nearly the entire contents of the new office. The League also hired its first paid employee, Mitch Glaze, to work in the office part-time to handle the League database.

The Astronomical League is alive and well and working for amateur astronomers everywhere. Except for Glaze, all officers and staff are volunteers, donating our time to further the goal of bringing astronomy to the people. This summer, the annual, per-member dues for the League increased to $5, an increase of $1.50 per member. For this small amount, each member receives the *Reflector* and all the benefits listed above — the best bargain available to amateur astronomers today. So, on behalf of all the volunteers who work for the League, we hope you will join us in this great hobby. A

Celestron has redesigned and improved two classic telescopes, making them nearly irresistible. /// BY PHIL HARRINGTON

Celestron's Advanced Series telescopes

The first go-to telescopes, introduced

a decade ago, had one thing in common: they were expensive. But as technology improved, telescopes became cheaper to produce, and amateur astronomers saw an amazing evolution. Even introductory-level telescopes were outfitted with scaled-down computer-controlled drives. The introductory systems — as well as the advanced go-to telescopes — were big hits, but in their wake, they left a void in the middle of the market. No mid-priced, computer-controlled telescopes were being built for the serious hobbyist.

As the telescope world continues to evolve, we're beginning to see that niche filled. The latest entries are Celestron's Advanced Series, which includes 4-inch and 6-inch refractors; 6-, 8-, and 10-inch Newtonian reflectors; and 5-, 8-, and 9¼-inch Schmidt-Cassegrain telescopes. These scopes are not new, having stood the test of time, but are redesigned instruments. What's underneath these telescopes, however, is new. Except for the C4-R refractor and C6-N reflector, the improved CG-5 equatorial mount supports these telescopes.

The CG-5

The CG-5 mount has been a staple at Celestron since the mid-1990s. The original design was adequate for handling modest instruments but began to teeter under the weight of more substantial telescopes. My own review of the Celestron G-9¼ Schmidt-Cassegrain in the June 2002 issue of *Astronomy* rated mounting stability as poor, commenting, "The guilty party here is the aluminum tripod. Like many imported tripods, the CG-5's is made from thin-walled, stamped aluminum."

THE CG-5 EQUATORIAL MOUNT is a go-to drive system. The CG-5 rides on a newly engineered tripod, which incorporates sturdy, tubular steel legs. *ASTRONOMY*: JAMES FORBES

To help steady the view, Celestron replaced the CG-5's original tripod legs with far more substantial, 2-inch tubular legs made of stainless steel. The legs measure 32 inches long when collapsed and extend to 56.5 inches. Further, the redesigned CG-5 mount's axes are smoother and more stable. The GT version of the mount adds a NexStar go-to system that features a database of more than 40,000 objects. When whizzing from one target to the next, the internal worm gear DC servo-motors move the telescopes at speeds up to 4° per second.

Of course, we wanted to find out how well the new Advanced Series CG-5GT mount performs. We also decided to test the optics of two of the most popular instruments in the line, so we put the C8-NGT Newtonian and C8-SGT Schmidt-Cassegrain through their paces.

Overview

Let's begin with the 8-inch f/5 C8-NGT Newtonian reflector. The C8-NGT's steel tube assembly is held in a pair of rings mounted to a dovetail bar that mates to the mount's saddle. The telescope can be moved back and forth in the rings, and the dovetail assembly can slide 13 inches along the saddle for precise balancing.

Celestron uses a thin metal plate to cover the back end of the Newtonian's tube to seal out dust. Although effective, it restricts access to the primary mirror cell's adjustment screws, which you'll need to collimate the optics. The plate also slows airflow through the tube, impeding the cooling process. I recommend you remove the plate altogether and — to keep dust from the optics — cover the end with a shower cap when the telescope is not in use.

C8-NGT (above) is Celestron's new 8-inch f/5 Newtonian reflector. This go-to telescope is a complete system that delivers superb optical performance. **THE C8-SGT** (right) is the latest in a generation of tried-and-true Schmidt-Cassegrain telescopes from Celestron. *ASTRONOMY*: JAMES FORBES

The other telescope, the C8-SGT, is built around Celestron's tried-and-true 8-inch f/10 Schmidt-Cassegrain frame. The test C8-SGT came with Celestron's new Starbright XLT coating, which is designed to increase light transmission by approximately 16 percent over optics with a standard coating. At its peak wavelength, the XLT coating reflects 89 percent of the light entering the telescope into the eyepiece. The coating works, as image brightness was excellent. The C8-NGT Newtonian, which is available only with standard aluminizing, reflects about 78 percent of the incoming light.

Each telescope was supplied with its own CG-5GT mount and tripod, enabling me to do side-by-side comparisons of optical quality as well as the chance to confirm mechanical consistency. Each mount included a NexStar hand controller, which features a two-line readout and a full-size keypad that I found easy to use even while wearing heavy gloves. The mount also can be controlled remotely using any of several planetarium-style programs, such as *TheSky* Level 1 software (included), by connecting an RS-232 cable between the hand controller and a computer.

THE HAND PADDLE is the heart of Celestron's NexStar computer control system. Coupled with the CG-5 equatorial mount, the hand controller provides go-to capability. *ASTRONOMY*: JAMES FORBES

Setup

I found setting up each telescope to be quick and straightforward. Open the tripod and extend the legs to the length you desire. Place the CG-5 mount on top of the tripod, line up the alignment pin with the recess on the underside of the mount, and tighten the knob on the tripod's captive central rod. Finally, slip the accessory tray onto the central rod, lining up the three arms of the tray so that each is pushing against the inside of a leg, and tighten the tray in place with a second large knob. With the tripod and mount connected, screw the counterweight bar into the declination axis and attach two 11-pound counterweights that come with the telescope. The C8-SGT can get by with just one counterweight if the scope is used for observing, but it will need both to counterbalance a camera.

Each telescope's computer and motors use 12-volt DC power. Because of power requirements, Celestron does not include a battery holder. Instead, Celestron includes a 24-foot cord to plug into an automobile cigarette lighter or rechargeable battery, which makes much more sense. A 110-volt AC adapter is sold separately.

Initializing the telescope's computer is straightforward and well detailed in the operating manual. Begin by roughly aligning the telescope with the celestial pole. When you turn on the power, the hand controller offers you four ways to initialize its settings: *Auto Align*, where the telescope chooses three stars; *Auto Three-Star Alignment*, where the user chooses three alignment stars from a list; *Quick Align*, where the telescope simply tracks the sky but cannot use the onboard computer for finding objects; and *Last Alignment*, which continues to use the alignment that was saved when the telescope was last turned off. I prefer *Auto Align* because it's easy and leads to accurate acquisition of objects.

THE NEWTONIAN DESIGN of the C8-NGT incorporates an 8-inch primary mirror at the bottom of the tube. Light is reflected off the primary to the secondary, which then reflects it to the eyepiece. *ASTRONOMY*: JAMES FORBES

Testing

To test the instruments, I aimed each at a 3rd-magnitude star. Checking the images both inside and outside of focus through the C8-SGT revealed a small amount of spherical aberration, which I confirmed with a Ronchi grating. Overall, I judged the telescope to have a final wavefront error of about ¼-wave, which is considered "diffraction limited." This means the telescope will perform up to the limits of atmospheric conditions.

Phil Harrington *is the author of the new observing guidebook* Star Watch, *which is published by John Wiley & Sons.*

In actual use, the small amount of spherical aberration clouded the view a tiny bit, especially on bright objects such as planets. Saturn had a slight haze around it but was still sharp enough for me to distinguish the Cassini Division as well as the planet's subtle equatorial belt. Close double stars, such as Castor and Rigel, were easy to resolve.

Switching scopes, I found the C8-NGT had some of the finest optics I've seen in a Newtonian reflector. Star testing proved the primary mirror was a nearly perfect paraboloid. Estimating its wavefront accuracy, I judged the mirror to be at least 1/10 wave, which translated into some stunning views of sky objects.

On a night when seeing conditions rated a 5 on a scale of 1 to 10, the C8-NGT delivered wonderful images of Saturn at 357x using a 7mm Pentax XL eyepiece and 2.5x Tele Vue Powermate. That same combination also showed six stars in the Trapezium (within the Orion Nebula). The C8-NGT also revealed lots of detail within Jupiter's turbulent atmosphere.

The NexStar go-to system performed wonderfully night after night. At each stop, the target was within the field of the C8-NGT's 20mm eyepiece (50x). Aiming accuracy was also good through the C8-SGT, although the narrower field of its 25mm eyepiece (81x) meant an occasional quick hunt for the target.

The overall stability of the Advanced Series CG-5 mount is better than earlier models thanks to the sturdier tripod. A direct comparison between the new CG-5 and my own, older CG-5 confirmed that vibration-dampening times have been cut in half with the new tripod.

Celestron has created an impressive line of intelligent telescopes with the Advanced Series CG-5GT family. The new CG-5 mount has undergone some welcome improvements, the NexStar go-to system proves to be a trustworthy companion, and the telescopes' optics, especially the 8-inch Newtonian's, are exceptional. Put all this together in a package that retails for between $950 and $1,500 each, and you have two great instruments that are sure to give owners enjoyment for years to come. A

/// CELESTRON C8-NGT AND C8-SGT SPECIFICATIONS

C8-NGT

8-inch f/5 Newtonian reflector
Oversized rack-and-pinion focuser with 1¼" and 2" eyepiece adapters
9x50 straight-through finder scope
NexStar computer control system
Extendable tripod
Accessory tray
20mm Plössl eyepiece
TheSky Level 1 CD-ROM
Retail price: $1,019
Total weight: 74.5 pounds
C8-N tube assembly: 21 pounds
Tripod and mount: 31.5 pounds
Two counterweights: 11 pounds each

C8-SGT

8-inch f/10 Schmidt-Cassegrain telescope
1¼" visual back and star diagonal
6x30 straight-through finder scope
NexStar computer control system
Extendable tripod
Accessory tray
20mm Plössl eyepiece
TheSky Level 1 CD-ROM
Retail price: $1,359
($1,514 with Starbright XLT coating)
Total weight: 66 pounds
C8-S tube assembly: 12.5 pounds
Tripod and mount: 31.5 pounds
Two counterweights: 11 pounds each

Contact information:

Celestron
2835 Columbia Street
Torrance, CA 90503
[t] 310.328.9560
[w] www.celestron.com

LOOKING DOWN THE TUBE of the C8-SGT reveals first the front corrector lens and then the primary mirror. The secondary mirror is attached to the center of the corrector lens. *ASTRONOMY*: JAMES FORBES

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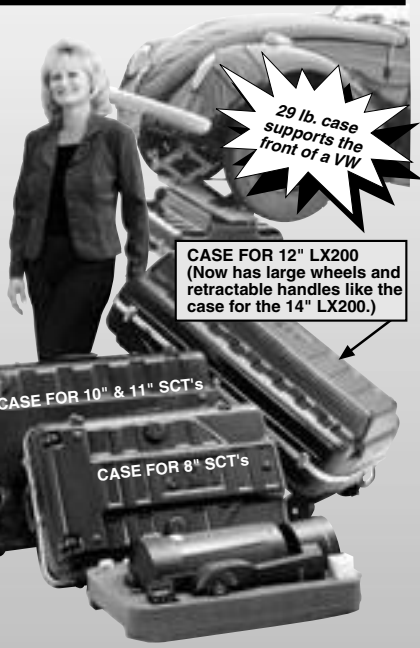
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For those who lived through the glory years of the Apollo program, the late 1960s and early 1970s seemed to provide a stream of astonishing missions to the Moon in such profusion that at least some of us came to view them as routine.

Reflecting on that achievement some 35 years later makes these flights all the more remarkable. Until now, video footage of America's lunar voyages has been confined to compilation documentaries with varying degrees of production value. Spacecraft Films has chronicled this era with a brilliant new series of DVDs unrivaled for completeness and detail.

Each package is devoted to an individual mission, including assembling the spacecraft's components. Each takes the viewer through raw footage of the crew suiting up, liftoff, docking, the journey to lunar orbit, undocking, landing, EVAs on the Moon, and the trip home. (The price for each mission's package reflects the number of DVDs it includes. Apollos 8 and 11, with three DVDs each, sell for about $45, while Apollo 15, containing six DVDs, costs about $85.)

The DVDs released thus far (covering Apollos 8, 11, 15, with 13, 16, and 17 coming later this year, and 12 and 14 in 2005) are unadorned with music, stylish editing, or cinematic embellishments of any kind. This is "Apollo unplugged."

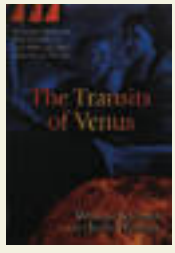
With running times averaging more than 10 hours per voyage, the DVDs don't make for a night of light family viewing. Rather, this series offers an unfiltered chronicle of the times and technology it took to land men on the Moon. They are as stark as a lengthy audio debriefing or as dramatic as a rover's wheels throwing Moon dust. Instead of a narrator waxing rhapsodic in voice-over about the era's achievements, Spacecraft Films lets the footage do all the talking.

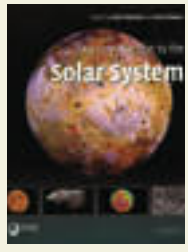
And it's plenty effective. You find it difficult not to get emotional when you witness the supernatural rush of a Saturn V lifting off the pad, or when you see John Young do a jumping salute on the lunar surface. In an era of reality TV, the Apollo series offers an ultimate reality trip without commercial interruptions.

The DVDs take advantage of the medium's capabilities by providing multiple camera angles on the launches and various audio tracks along the way. These let the viewer use the DVD player's remote control to choose which version to see or hear. Additionally, when NASA jargon flies fast and furious between the crew and mission control, the acronyms are handily translated on the screen for the viewer.

Much of this footage has not been seen by the public since the day it was shot — if at all. Spacecraft Films obtained it by searching NASA and National Archives files. Then, the company digitally corrected the footage for proper color and clarity.

The series also serves to humanize the missions by allowing us to see rare close-ups of young polo-shirted crews who exude an extreme casual confidence in the midst of "go fever." These disks chronicle what extraordinary men did in extraordinary times. — **KEN LEVY** *is a New-York-based writer and member of the Amateur Astronomers Association of Princeton.*





The Transits of Venus

William Sheehan and John Westfall, 407 pages, Prometheus Books, Amherst, New York, 2004; ISBN 1–59102–175–8; hardcover, $28.

Seeking to measure the solar system, astronomers in the 17th through 19th centuries traveled the globe to observe Venus on its rare passages across the solar disk. In addition to explaining the science behind their efforts, Sheehan and Westfall tell the amusing (and sometimes appalling) stories of what these astronomers experienced on their journeys. They provide a clear look at how yesteryear's astronomy was practiced. Another good, if somewhat briefer, "transit book" is Eli Maor's *Venus in Transit* (Princeton University Press, 2004; $17.95), which updates a work first published in 2000.

An Introduction to the Solar System

Neil McBride and Iain Gilmour, eds., 412 pages, Cambridge University Press, New York, 2004; ISBN 0–521–54620–6; paperback, $65.

As spacecraft fly past, orbit, or land on various planets and moons in the solar system, it's easy to get lost in the welter of data fired back to Earth. This book by five United Kingdom scientists provides the Big Picture necessary for understanding new discoveries. The organization revolves around topics (such as planetary volcanism, atmospheres, and surface processes) rather than specific bodies, which helps make the picture clearer. Math is used sparingly, but to good effect.

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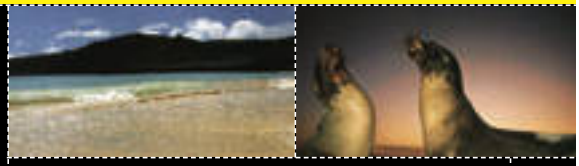

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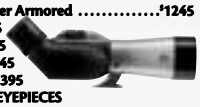

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Naked-eye astrophysics
The Sun is surrounded by a ring of bright stars called Gould's Belt. Visible to the naked eye, these stars were born just a few million years ago in a burst of star-making.

Cassini meets Phoebe
The Cassini spacecraft makes its first close approach to a member of the saturnian system on June 11, passing within 1,200 miles of the captured moon Phoebe.

Shooting the sky
In the digital age, some of the best astrophotographers still are using 35mm film to record their images. Learn the secrets and see some examples from two of the best, Bill and Sally Fletcher.

Canon 10D review
Electronic images of deep-sky objects once were obtainable only with expensive and complicated CCD cameras. Not anymore! Be amazed by the images created with Canon's easy-to-use digital SLR.

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08.12.04–08.15.04

Now located about an hour's drive

from Prineville in the Ochoco National Forest, the Oregon Star Party (OSP) began humbly in 1988: a dozen Portland-area stargazers assembled near the peak of Steens Mountain. Last year's gathering drew more than eight hundred

THE HAZE hovering over this sunset was caused by fires in the Cascade Mountains. While the smoke limited viewing at the 2003 OSP, it did act as a good filter for observing Mars. JAN KEISKI

international participants, the largest attendance to date. OSP organizers expect even more people this year.

This star party brings together a great medley of users, some with large home-made telescopes or scopes with sophisticated tracking systems, and those who prefer using smaller models, binoculars, or their naked eyes.

The clear, dark sky isn't the only attractive feature of the OSP. Nature lovers show up not only for observing but also to camp among the ponderosa, juniper, sage, and wildlife of the region.

For more information, e-mail ospinfo@patch.com; web site, *www.oregonstarparty.org*.

08.11.04–08.15.04

Great Manitou Star Party

Aundeck Omni Kaning, near Little Current, Manitoulin Island, Ontario, Canada. This year's event arrives just in time for the Perseid meteor shower. Guests on the island will be treated to an eclectic mix of music, indigenous culture, and astronomy. For more information, contact Mark Oldfield at 705.897.4518; e-mail, greatmanitou@hotmail.com; web site, *manitoulindarksky.com*.

08.13.04–08.15.04

Indiana Family Star Party

Prairie Grass Observatory, Camp Cullom, near Frankfort, Indiana. Hosted by the Wabash Valley Astronomical Society, Indiana Astronomical Society, and Calumet Astronomical Society, this gathering encourages families, regardless of astronomical knowledge, to attend. For more information, contact Russ Kaspar at 765.659.4451; e-mail John Mahony at jmmahony@hotmail.com; web site, *indianastars.us*.

08.13.04–08.15.04

Northwoods Starfest

Hobb's Observatory in the Beaver Creek

Reserve, near Eau Claire, Wisconsin. Known for its relaxed atmosphere and dark sky, this is the 16th annual gathering at Hobb's Observatory. A 5-meter dish at the observatory will be of interest for fans of radio astronomy. For more information, contact Bert Moritz at 715.835.4034; e-mail, moritz@charter.net; web site, *www.cvastro.org*.

08.14.04

Lake Whitney Star Party

Lake Whitney State Park, Whitney, Texas. One of the best bargains in star parties, it only costs $2 to attend this event. Besides observing, attendees will enjoy a guest speaker, door prizes, and awards. For more information, contact Thomas Williamson at 6505 Hightower Drive, Watauga, TX, 76148; phone, 817.656.0901; e-mail, distglow@sbcglobal.net; web site, *whitney-astro.com*.

08.14.04–08.22.04

Mt. Kobau Star Party

Near Osoyoos, British Columbia, Canada. The 21st gathering will be held among the sagebrush and conifers of one of Canada's finest mountain sites for observing. Daytime activities from August 19–22 will include lectures and contests. For more information, contact Registrar James McRae at P.O. Box 20119 TCM, Kelowna, B.C., Canada, V1Y 9H2; e-mail, info@mksp.ca; web site, *www.mksp.ca*.

08.14.04–08.15.04

Toledo Astronomical Association Summer Star Party

Pioneer Scout Reservation, Pioneer, Ohio. Bringing in astronomers from throughout the Midwest, the reason for this party is to celebrate the relocation of their 25-inch scope. For more information, e-mail either Don Murad at dmurad@uoft02.utoledo.edu or Alan White at alanwhite@acsitoledo.com.

08.19.04–08.22.04

Starfest

The River Place, near Mount Forest, Ontatrio, Canada. The largest star party in Canada, this year's gathering will feature lectures by prominent astronomers Terence Dickinson, David Dunham, Robert Gendler, and Ivan Semeniuk. For more information, visit *www.nyaa-starfest.com*.

08.22.04–08.24.04

Solar Eclipse Conference 2004

Open University, Milton Keynes, England. The objective of this conference is to bring together professionals and amateurs to discuss all aspects of solar eclipses. Two days of lectures will be given in these disciplines: mathematics, predictions, diameter measuring, solar physics, weather forecasting, eye safety, and ancient eclipse research. The 2004 transit of Venus also will be a discussion topic. For more information, e-mail solareclipsewebpages@btopenworld.com; web site, *solareclipsewebpages.users.btopenworld.com*.

09.16.04–09.19.04

Illinois Dark Skies Star Party

Jim Edgar Panther Creek State Fish and Wildlife Park, near Springfield, Illinois. Outdoor activities such as hiking, horseback riding, and fishing provide something to do when not behind the eyepiece. For more information, visit *www.sas-sky.org* or *www.slasonline.org*.

09.16.04–09.18.04

Astrofest

Vana's Farm, Kankakee, Illinois. Sponsored by the Chicago Astronomical Society, this is the 25th annual gathering. *Astronomy* staff members will attend this star party. For more information, call Walter Glogowski at 847.910.2878; e-mail, casdarksky@ameritech.net; web site, *www.chicagoastro.org*.

CONTACT INFORMATION

Please submit club announcements four months in advance to Coming Events, *Astronomy*, P. O. Box 1612, Waukesha, WI 53187, or jmcgovern@astronomy.com. Also use this e-mail address to submit your events for our on-line calendar.

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WEB — Although you can't observe with the CFHT atop Mauna Kea, you can experience the thrill of observing at a world-class observatory by signing up for a night on Kitt Peak in southern Arizona through the Advanced Observer's Program (AOP). Using a 20-inch telescope, you'll be able to create images of your favorite astronomical objects. Not an imager? No problem. The AOP's director, Adam Block, will guide you through every step of the process, from exposures through image processing. Find the AOP at *www.noao.edu/outreach/aop*.

SEEKING OTHER EARTHS

BOOKS — In a field where discoveries are frequent, books on extrasolar planetary systems and searches run a good way behind the leading edge. Articles in journals (e.g., *Astrophysical Journal*) are more up to date but often formidable to non-professionals. For a more accessible approach, take a look at *New Worlds In the Cosmos* by Michel Mayor and Pierre-Yves Frei (Cambridge University Press, New York, 2003). This book explores the history of exoplanet searching and describes the systems found through October 2002.

Interested young astronomers can take a trip to an alien world in Paul Halpern's nonfiction book *Faraway Worlds,* illustrated by Lynette Cook (Charlesbridge Publishing, Watertown, Massachusetts, 2004).

WEB — The best place to stay current with the state of exoplanet searching is the Extrasolar Planets Encyclopaedia, *www.obspm.fr/encycl/encycl.html*. This web site is updated daily (or nearly so). It maintains a current list of discoveries, statistics, meetings and publications, and links to many search programs' sites.

Backyard astronomers with a medium-size telescope and CCD camera should check out *www.transitsearch.org*. This program offers skilled amateur astronomers the opportunity to help in the search for exoplanets transiting stars.

Finally, if you don't mind wading through professional literature, visit the preprint server at *arxiv.org* to search for new findings in the "Astrophysics" section.

WARM AND NOT SO FUZZY

WEB — Keep track of the latest results from the Spitzer Space Telescope at the observatory's official site, *www.spitzer.caltech.edu*. The site includes all the publicly released images (including wallpaper and screen savers for your personal computer), news releases, and the science details behind Spitzer and infrared astronomy in general.

Spitzer is the fourth and final element in NASA's Great Observatories program. The Hubble Space Telescope, which was launched in 1990 and is still going strong, was the first of these remarkable observatories (*hubble.stsci.edu)*. Second was the Compton Gamma Ray Observatory (*cossc.gsfc.nasa.gov/cossc*), which was deployed from the space shuttle in 1991 and purposely brought down in the Pacific Ocean in 2000. The third component, the Chandra X-ray Observatory (*chandra.harvard.edu/index.html*), rode into space in 1999 and continues to observe the high-energy universe.

To see some results from the pioneering Infrared Astronomical Satellite (IRAS), visit *coolcosmos.ipac.caltech.edu/image_galleries/IRAS/irasgallery.html.*

BARNARD'S MILKY WAY

BOOKS — William Sheehan's *The Immortal Fire Within: the Life and Work of Edward Emerson Barnard* (Cambridge University Press, New York, 1995) is a well-researched biography of Barnard that runs more than four-hundred pages.

To gain a picture of astronomy during the time Barnard was working, take a look at Donald Osterbrock's *Pauper & Prince* (University of Arizona Press, Tucson, 1993). It is a joint biography of George Ellery Hale and George Ritchey that provides much detail about the issues astronomers were studying at the turn of the 20th century.

To see how astronomers struggled with the idea of material drifting through space among the stars (and the role Barnard played in resolving the issue), see Gerrit Verschuur's *Interstellar Matters* (Springer-Verlag, New York, 1989).

WEB — Yerkes Observatory offers a virtual museum at *astro.uchicago.edu/yerkes/virtualmuseum,* and if you click on the "People" link, you'll find a link to a short biography of Barnard with pictures.

In 1917, Barnard won the Bruce medal of the Astronomical Society of the Pacific. The page at *www.phys-astro.sonoma.edu/BruceMedalists/Barnard/index.html* contains links to articles on his life and career.

EXTREME IMAGING

WEB — Looking for an adventure of your own? Join *Astronomy* and Mayhugh Travel on a journey to Mauna Kea in the spring of 2005. Tour the professional research scopes at the summit, star-gaze under the dark Hawaiian sky, and visit other sites of interest. For more information, read editor Dave Eicher's account in "From heaven on Earth . . . into thin air"(*Astronomy*, January 2004), and then check out *www.astronomy.com/content/static/trips* to sign up for this and other exciting tours.

A LEAGUE OF ITS OWN

WEB — This astronomy "club of clubs" is located at *www.astroleague.org*. The site covers everything from League history to educational outreach programs to the many observing clubs. Membership information also is available, both for clubs as a whole and for members-at-large, patrons, or supporting members.

Another benefit offered to Astronomical League members is the on-line store. Through a secure server, you can order League publications, observing aids, astronomy books, and several useful items with the League's logo on them.

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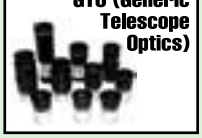

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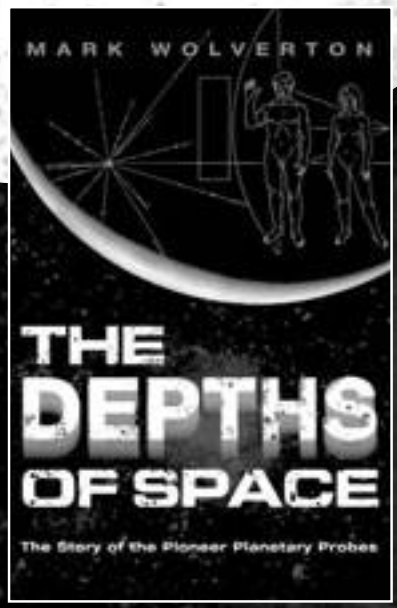

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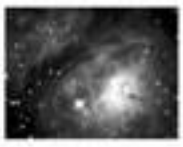
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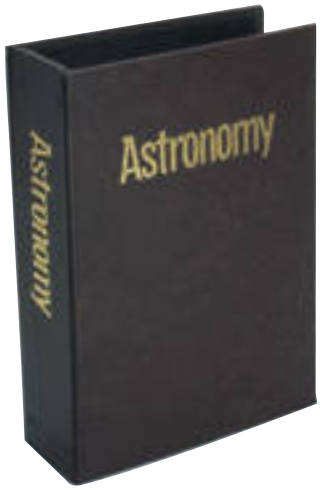

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Reader gallery

Readers share their images...

Comet Bradfield /// Comet C/2002 T7 (LINEAR) /// The Whirlpool Galaxy /// Orion
A reflection nebula /// Barnard's Galaxy /// A northern lights display

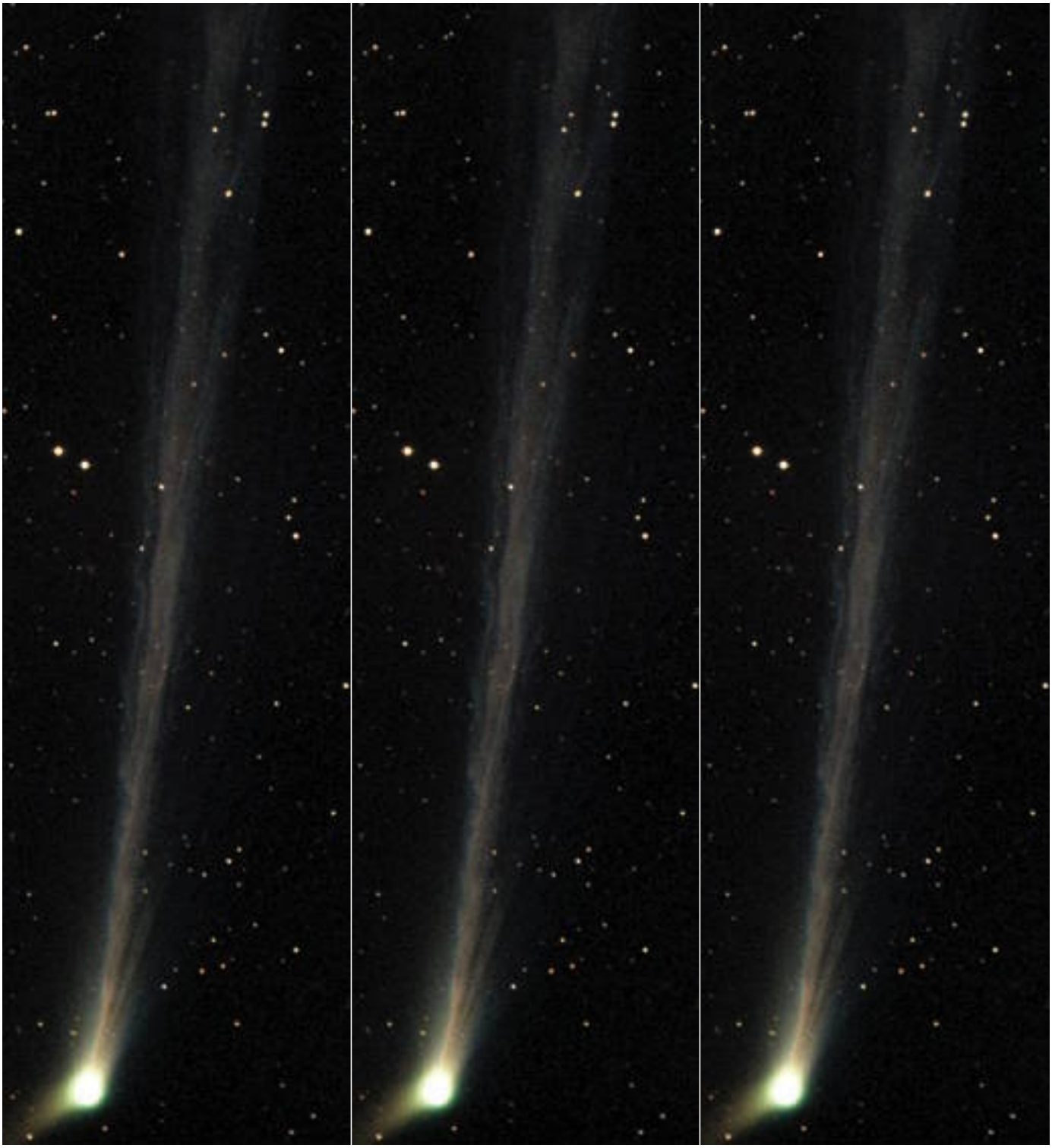
COMET BRADFIELD (Canon EOS 300D Digital Rebel, 20mm lens at f/2.2, 20-second exposure at ISO 800, taken April 24, 2004, at 4:10 A.M. MDT) TOM POLAKIS

A BEAUTIFUL COMET

Comet Bradfield

While amateur astronomers were starting to observe the two predicted springtime comets, C/2002 T7 (LINEAR) and C/2001 Q4 (NEAT), something amazing happened. A new comet was discovered that outshone them both. Comet C/2004 F4 (Bradfield) was discovered on the evening of March 23, 2004, by William Bradfield, an Australian amateur astronomer and comet hunter, with a homemade 10-inch Newtonian reflecting telescope. C/2004 F4 is Bradfield's 18th comet discovery since he began searching for them in 1972. C/2004 F4 was brightest a month after its discovery. At that time, observers could follow its tail through binoculars as it stretched 20° across the sky — even in morning twilight.

Send your photos to: ASTRONOMY reader gallery, P.O. Box 1612, Waukesha, WI 53187; e-mail to readergallery@astronomy.com. Please include your full name, date and location of image, and complete photo data: telescope, camera, film, and exposure information.



CHANGES IN COMET C/2002 T7 (LINEAR) (3-inch Tele Vue-76 apochromatic refractor at f/6.3, SBIG ST-10XME CCD camera, RGB images with exposures of 5 minutes in each color, taken April 22, April 24, and April 28, 2004, respectively, at 11h00m UT each morning, from Kitt Peak National Observatory, Arizona) LEFT TO RIGHT: SVEND AND CARL FREYTAG AND ADAM BLOCK; PHILIP DARLING, TERESA HAWES, AND ADAM BLOCK; PAT BALFOUR, CURT HARRIS, AND ADAM BLOCK

Below, **REFLECTION NEBULA IC 63** (8-inch Celestron Schmidt-Cassegrain telescope at f/6.10, Starlight Xpress SXV-H9 CCD camera, LRGB image with exposures of 300, 10, 10, and 10 minutes, respectively) WOLFGANG PROMPER

Top left, **THE WHIRLPOOL GALAXY (M51)** (12.5-inch Optical Guidance Systems Ritchey-Chrétien telescope, ST-10XE CCD camera, LRGB image comprised of twenty-five 7-minute exposures in L, five 5-minute exposures in R and G, and eight 5-minute exposures in B) TED WOLFE

Bottom left, **ORION SETS IN THE DESERT** (Olympus OM-1 35mm camera, 50mm lens at f/2.8, Kodak Elite Chrome 400 film pushed one stop, 20-second exposure) JOE ORMAN

Bottom right, **BARNARD'S GALAXY (NGC 6822)** (8-inch Takahashi Epsilon 210 hyperbolic astrograph, SBIG ST-8XE CCD camera, LRGB image with exposures of 60, 20, 20, and 20 minutes, respectively) RICH JACOBS

SPECTACULAR AURORA (Canon EOS3 digital camera, Sigma 20mm lens at f/2, Fuji Provia 400F film, 15-second, tripod-mounted exposure taken November 20, 2003, from the Yukon Territory, Canada) ROBERT POSTMA

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